MEKELLE UNIVERSITY

Performance of Farmer Managed Bovans Brown Layers Fed on Different Locally Available Rations

By

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A thesis

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ABSTRACT

The study was conducted to evaluate the effects of feed supplementation on feed intake, body weight change, feed conversion efficiency, egg production, morbidity, mortality, egg quality and profitability of Bovans Brown layers for 90 feeding trial days under farmers management. Randomized Complete Block Design was used with 4 treatments and 5 replications each. A total of 100 Bovans Brown layer with uniform Body weight and age were blocked randomly into 20 farmers 5 bird per farmer and were allocated randomly in to one of the 4 dietary treatments. Locally available feed resources (maize, nouge cake, sesame meal, limestone and salt) were used to formulate the experimental diets. The CP and ME content of treatment rations ranged 12.5- 16.87% and 2245-2909.51kcal/ kg DM, respectively. The amount of feed consumed was determined by obtaining the difference between the quantity feed offered and the quantity feed remaining on the feed trough. Body weight of the birds was measured at the beginning and end of the study. Egg quality traits were determined six times during the study period by taking three eggs from each farmer per two week. The result from the analysis of variance shows that, DFI % of the treatment rations (0, 96.425, 97.575 and 97.301 (SEM=9.646)); BWG (g/bird) (32.0, 56.8, 62.0 and 61.6 (SEM=3.538)); HDEP (%) (49.244, 56.668, 60.356 and 58.74 (SEM=1.006)); HHEP (%) (49.244, 56.668, 60.356 and 57.51) (SEM=0.971)); egg weight (g) (55.3, 56.1,56.2, and 56.3 (SEM=0.102));egg mass(g/hen/day (27.26,31.37,32.07and 33.07(SEM=0.527)); FCE(g of eggs/g of feed (0.00, 0.972,1.096 and 1.08 (SEM=0.105)); Mortality by predator (%) (0,0,0 and 8 (SEM=2)); Shell weight (g) (4.908,5.312,5.354,5.35(SEM=0.055)) and shell thickness(mm) (0.368, 0.388, 0.398 and 0.386 (SEM=0.004)) were analyzed for T1, T2, T3, and T4 , respectively. The result shows production performance and egg quality traits except Albumen quality and yolk colour were affected by feed supplementation .The partial budget analysis of the birds in T1, T2, T3 and T4 was calculated as 3324.00, 3385.68, 3499.00 and 3427.35 net return in Ethiopian birr respectively ; indicated that net return increased as the level of dietary protein and dietary energy increased because these nutrients improved the production performance and egg quality traits of hens. Therefore, it is concluded and recommend that feed with comparatively higher 16.87% CP and slightly lower 2752 kcal/kg ME diet could be better for BB layers under farmer's condition. Protein-rich feeds are expensive **.***Hence; future research should focus on the possibility of using cheap conventional and non-conventional protein-rich feed resources as feed supplement for scavenging chicken. The egg quality from Bovans Brown layers was a good quality at village level, while the average number of eggs/bird/year may need further study through considering the amount of feed provided by the farmers and scavenging feed resources on that area by crop analysis.*

Keywords: Bovans Brown, egg production, egg quality, feed supplementation.

DECLARATION

I, Eyesus Tekulu Welay hereby present for consideration by the Department of Animal, Range and Wildlife Sciences Department within the College of Dry land Agriculture and Natural Resources at Mekelle University, my dissertation in partial fulfillment of the requirement for the degree of Masters in **Performance of Farmer Managed Bovans Brown Layers Fed on Different Locally Available Rations**. I sincerely declare that this thesis is the product of my own efforts. No other person has published a similar study which I might have copied, and at no stage will this be published without my consent and that of the Animal, Range and Wildlife Sciences department.

Name of the student ______________________ Signature & date ____________________

Approval

Name of the main adviser__________________ Signature & date ___________________

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Name of external examiner__________________Signature & date ___________________

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Name of Postgraduate coordinator ____________Signature and date _________________

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Name of CRPCS____________________Signature & date_________________

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ABREVIATIONS AND ACRONOMYS

ANOVA	Analysis of variance
BB	Bovans Brown
BW	Body Weight
BWG	Body weight Gain
CSA	Central Statistics Agency
CV	Coefficient of Variation
CF	Crude Fiber
CP	Crude Protein
DM	Dry Matter
EM	Egg Mass
EE	Ether Extract
FCF	Feed Conversion efficiency
FAO	Food and Agricultural Organization
Gm	Gram
HDEP	Hen-Day Egg production
HHEP	Hen-Housed Egg production
Kcal	Kilo calorie
Kg	Kilo gram
ME	Metabolize able Energy
RCBD	Randomized Complete Block Design
SAS	Statistical Analysis Software
SFRB	Scavenging Feed resource base
SEM	Standard Error of mean

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CHAPTER 1: INTRODUCTION

1.1. Background and Justification

There is a growing attention and interest in poultry production worldwide, as being a tool in poverty alleviation (Riise *et al.*, 2005).The major reasons for keeping chicken are for provision of animal protein, generating of extra cash income and religious /cultural considerations (Dessie and Ogle, 2001) and (Tadelle *et al*., 2003). The fast-growing human population, urbanization ,anticipated income growth and more purchasing power has boosted the demand for poultry products, and this has led directly to expansion of poultry production particularly within urban and peri-urban areas ; for instance chicken and eggs consumption have increased during the Ethiopian New Year, Christmas and Easter holidays (Aklilu *et al*., 2007).Therefore, it is expected to increase poultry production, besides other livestock development efforts in order to satisfy the growing demand of the society (Mengesha *et al.*, 2011). The total chicken population in Ethiopia is estimated to be 60.5 million with regard to breed 94.33% indigenous, 3.21% hybrid and 2.47% exotic breeds (CSA, 2016).

Poultry production as an integral part of livestock production system plays an important socio-economic role in developing countries (Alders, 2004) and (Kondombo, 2005). Poultry meat and eggs are estimated to contribute 20 to 30% of the total animal protein supply in low income food deficient developing countries (Sonaiya and Swan, 2004). The livestock sector has been contributing considerable portion to the Ethiopian economy. Livestock accounts for 16.5 % of national GDP and 35.6 % of agricultural GDP (Metaferia *et al.*, 2011).

The rural poultry production in Ethiopia contributes about 98.5% and 99.2% of the national egg and poultry meat production, respectively (Alemu and Tadelle, 1997). Exotic chicken breeds contribute less than 2% to the national eggs and meat production (Tadelle *et al*., 2000).In the rural areas of Ethiopia almost every family owns chicken and practice traditional chicken production system which provide valuable sources of family protein and income (Tadelle *et al*., 2003). Thus poultry play an important role in the diet and economy of the people.

There are various advantages which make poultry attractive in the context of poverty alleviation and an important sector in livestock production compared to the other livestock production .This is because of poultry has short generation intervals, good environmental adaptation to most areas of the world, small farming space requirement, and can be raised with relatively low capital investment (Daghir, 2001). Smallholder farming families, landless youth and people with incomes below the poverty line are able to raise chicken with low inputs and harvest the benefits of eggs and meat via scavenging feed resources (Sonaiya, 2004).

Even though poultry production has the above-mentioned advantages, in Ethiopia the economic contribution of the sector is not still proportional to the huge chicken resources. For instance the total chicken, egg and meat production in Ethiopia during the year 2012 is estimated 40000 and 60480 ton respectively (Faostat, 2013) ,which is reared and consumed by rural communities (Dessie and Ogle, 1996). (Sonaiya and Swan, 2004) reported that keeping poultry is for substantial contribution to household food security throughout the developing world. (Alemu and Tadelle, 1997) reported that village chicken production in Ethiopia characterized by no proper poultry feeding management, not market oriented, low input and local breeds. The major feed resource are from the scavenging feed resource base, which comprised table leftovers, small grain

, grain products from cultivating, harvesting and anything edible from the immediate environment (Pagani and Wossene, 2008). Scavenging poultry are usually capable of finding feeds for their maintenance requirement and few egg production and are vulnerable to predators and spread of infection (Dessie and Ogle, 1996)**.** (Tadesse, 2014) reported that the average number of eggs lay per hen per clutch was 13.6 for local hens, 25.7 for cross breed hens and 44.4 for exotic (RIR) under rural households. Under village production system, mean annual eggs laid/ hen/year of Isa Brown 276.1, Bovans Brown 266.3 and Potchefstroom Koekeoek 187.04 (Tadesse, 2012)**.** The current level of on-farm productivity in the smallholder production system is low due to various factors such as low genetic potential of the chicken, the poor feeding and management conditions.

Even though there is some research done in the area of supplementary feeding in rural households; rural people almost not yet used industrial by product protein and energy source as supplementary feeds for poultry chicken. In the central and eastern zones of Tigray region, limited oil crops, mainly noug and sesame seed cakes are used as supplements to the poor quality livestock feeds (Tesfay *et al*., 2016). However the dramatic increases in consumer demand for poultry products, mainly in urban areas have increased from time to time. To fulfilled the consumer demand scavenger feeding is not enough which is low input and low out production (Tadelle *et al*., 2002).Therefore, by minimizing the production constraints through use of exotic productive poultry breed (Bovans brown) as well as improvement of the production system (feed and feeding, housing, health, etc), it is possible to supply chicken products for the market demand over the household consumption with better quality. Hence, focusing on the utilization of locally available and affordable new ingredients that are not in direct competition with human food is important (Girma *et al*., 2011). This study was focused to determine the Performance of Bovans Brown layers fed on different locally available feed resources under farmer's management condition.

1.2. Statement of the Problem

Poultry production is widely being promoted in Tigray region in both urban and rural areas as the means of job opportunity and poverty reduction. Government and non-governmental organizations are working to enhance the private sector (Fitsum and Aliy, 2014). Hence, People investing in poultry production are increasing from time to time.

However this business venture is constrained by many factors among these factors inadequate feed availability with quality and inadequate feeding is the critical constraint in poultry production. The nutritional status of scavenging chicken in rural areas was found below the nutrient requirements of growers and layers for optimum performance. The CP and ME intakes of scavenging hens were at about 30% of the intake of confined hens by crop content analysis (Minh, 2005). Feed consumed by scavenging chicken contain an average low nutrient concentration of protein (100 g kg DM^{-1}), energy (11.2 MJ kg DM^{-1}) and minerals such as Ca (11.7 g kg DM^{-1}) and P (5 g kg DM^{-1}) (Goromela *et al*., 2006).

The low concentration indicates that the amount of nutrients from scavenging feed resource base /SFRB /alone cannot support optimal growth and egg production and needs supplementation of both energy and protein to improve the productivity of scavenging local and improved hens.

The expansion of agro-processing industries increases from time to time and the availability of industrial by-products /Noug cake, sesame cake and maize bran, wheat bran e.t.c/ is also increasing ; so using these industrial by-products which are high source of protein and energy as poultry feed improve poultry production and productivity. Therefore, this study is designed with the following objectives:

1.3. Objectives of the Study

1.3.1. General objective

- To study the performance of farmer managed Bovans brown layers fed on different locally available rations.

1.3.2. Specific objectives

1. To evaluate the effect of locally available feed resources on feed intake, body weight change and feed conversion efficiency of layers under farmer's management.
2. To evaluate egg production performance, morbidity, mortality, and egg quality traits of layers fed on locally available feed resources under farmer's condition.
3. To evaluate the profitability of farmer managed Bovans brown layers fed on different locally available rations.

1.4. Hypotheses

HO: Providing with different locally available feed resources will not have significant effect on feed intake, body weight change, feed conversion efficiency, egg production, morbidity, mortality, egg quality traits and profitability of farmer managed Bovans brown layers.

1.5. Significance of the Study

The livestock producers have currently limited contribution from poultry production due to low level of traditional feed and feeding system, which is mainly depend on scavenge and lack of appropriate feeding techniques. In rural area poultry feeds are cereal based and there is a competition between human and poultry for the same feedstuffs. It is therefore important to reduce feed competition between human and poultry by shifting the poultry feed to conventional feedstuffs or by product of agro processing .Therefore this study was focused on feeding strategies typically involves identifying and illustrating effects of conventional locally available feedstuffs and how to use efficiently to maximize poultry productivity and product quality as result to improve the livelihood of the society. Hence, the main target of this research is to address people and organizations that provide advisory, research, production and technical support services to rural farmers and small scale poultry producers.

CHAPTER 2: LITERATURE REIVEIW

2.1. Status and Role of Poultry Production in Ethiopia

Ethiopia has diverse agro-climatic conditions favoring production of many different kinds of crops, providing a wide range of ingredients and alternative feedstuffs suitable for poultry feeding. Indigenous chicken are distributed in different agro-ecologies and regional states where they depend primarily on what nature offers to sustain their life (Reta, 2009).

Poultry production systems in Ethiopia show a clear distinction between traditional, low input systems on the one hand and modern production using relatively advanced technology (Yami, 1995). According to (Yami, 1995), backyard type production, in which native fowl scavenge for most of their food, predominates and is widespread in the rural community . Moreover, indigenous chicken are known for their good merits such as broodiness behavior with high fertility and hatchability, disease resistance, thermo tolerant, hard eggshells and meat flavor (Abera, 2000). According to (Reta, 2009) Ethiopian on-farm indigenous chicken's mean egg yield per hen per year ranges from 40-45 eggs with the average egg weight 39-42 g. Therefore, production and productivity of chicken remains low.

In general poultry production has economical contribution to the livelihoods of poor households. This is because of chicken are efficient in transforming feed to protein and energy to human diet; chicken serves as a simple means of generating family income and employment opportunities, contributes economically as starter capital, as a means to recover from disasters, for socio mystical functions, hospitality and exchange of gifts to strengthen social relationship and as source of organic fertilizer for crop cultivation to the livelihoods of poor households (Farrell, 2013) and (Aklilu *et al*., 2008).

However, the indigenous chicken have been neglected in areas of scientific research on identifying distinct line breeds and its characterization, production performance, potential improvement and system of development efforts. Commercial poultry breeders and farmers in Ethiopia rely on exotic chicken because of their higher productivity above local strains. Therefore the current study shows that there is a possibility for improvement of egg production in the village through introduction of relatively few inputs like improved egg type breeds, feeds and feeding strategies.

2.2. Poultry Production Systems in Ethiopia

The poultry sector in Ethiopia can be characterized into three major production systems based on some selected parameters such as flock size, housing, feeding, health, technology and bio-security system (Alemu and Tadelle, 1997) and (Bush, 2006).These are village or backyard poultry production system, small-scale commercial poultry production system and large scale commercial poultry production system. These production systems have their own specific chicken breeds, inputs and production properties. Each can sustainably coexist and contribute to solve the socio-economic problems of different target societies (Tadelle *et al*., 2003).

2.2.1. Village/backyard/ chicken production systems in Ethiopia

Village chicken Production Systems is the most common production system practiced in the major farming community with irregular supplementation of cereal grains with the objectives of the production for household consumption and for additional income for the household. It has been estimated that 80% of the poultry population in Africa is reared in traditional scavenging system (Guèye, 2000). The rural poultry sector in Ethiopia constitutes about 98% of the total chicken population (FAO, 2007). The village production system contributes about 98.5% and 99.2% of Ethiopian egg and poultry meat with annual output of 78,000 metric tons of eggs and 72,300 metric tons of meat (Alemu and Tadelle, 1997).

Flocks are small in number in each household consisting 7-10 birds from all age groups 2 to 4 adult hens, one male bird and a number of growers of various ages (Alemu *et al*., 2008) and (Dessie and Ogle, 1996). Mostly, indigenous chicken and some hybrids and exotic breeds may be kept under this production system (Alemu *et al*., 2008).

Village chicken production is cheaper production system compared to other production systems (Dessie and Ogle, 2001). Because, it requires lower inputs such as little investment costs of the foundation stock, simple night shades, a few handfuls of local grains and used family labour and very little medication cost. (Guèye, 1998) reported that village chicken are with good quality eggs and meat flavor, hard shell eggs, high dressing percentages and lower production costs. (FAO, 2009) reported that traditional chicken production is very cheap, but nutritional needs of the birds are difficult to meet. (Tadelle *et al*., 2003) reported that village birds are non-descriptive; surviving on irregular supplies of feed and water, and with no health care, and are part of a balanced farming system.

Scavenging is almost the common source of diet in village chicken production systems (Dessie and Ogle, 1996) and (Dessie and Ogle, 2000) . The quantity and quality of SFRB for scavenging poultry varies with season, altitude, climatic conditions, farming activities as well as social, management and village flock biomass. Scavenging laying hen can find approximately 60 to 70% of their feed requirement (Rahman et al., 1997). (Minh, 2005) reported that the mean weights of crop contents were about 50% higher for the rainy season compared to the dry season, and lower for the local breed compared to the improved breed. Chemical composition of the crop contents of scavenging hens range from three of the seasons short rainy, rainy and dry was analyzed and the result shows , DM, CP, CF, EE , Ca, P and ME levels of crop contents were 26.4-85.8%, 4.3-15.4% , 6.5-14% , 0.3-4.7%, 0.2-1.9% , 0.1-2.4% , 2245.1-3528.1 Kcal/kg DM, respectively (Dessie and Ogle, 2000). Crude protein, calcium and phosphorus levels which is below the requirements for egg production and growth (Mekonnen *et al*., 2010).

Flock productivity of this production system is low, compared to other production systems. This is due to sub-optimal management, lack of supplementary feeds, low genetic and disease (FAO, 2009) .Scavenging result in lower egg production and increases mortality (Dana and Ogle, 2002)**.** The mean annual egg production of indigenous chicken is estimated at 40-60 small eggs with thick shells and a deep yellow yolk color which is low egg production and high mortality (Moredaa and Mesekel, 2016). According the study by (Dessie and Ogle, 2001), scavenging without supplement is insufficient for good egg production . According to (Yami, 1995) and (Alemu and Tadelle, 1997), one of the main reason for low productivity of poultry production in Ethiopia is the poor feeding system .Moreover village poultry production often encounters problems related to lack of organization, which implies that local inputs, such as feed, medication, veterinary Services, and training. Therefore the amount of nutrients from SFRB alone cannot support optimal growth and egg production of village poultry and needs feed supplementation.

2.2.2. Commercial Poultry Production

The commercial poultry production system comprises small scale and large scale commercial production systems found distributed in a limited urban and pri-urban areas in Ethiopia, as it demands electricity, infrastructure and investment for intensification (Reta, 2009). Private and government enterprises are involved in this production system. It is estimated that this production system accounts for nearly 2% of the national poultry population in Ethiopia.

2.2.2.1. Small-Scale Commercial Poultry Production

The small-scale commercial poultry production (semi-intensive production System) is the system between the two extremes of traditional and commercial production systems, which is characterized by medium level of feed, water and veterinary service inputs and minimal to low bio-security with small to medium-sized flocks (50 to 500 birds) meat and egg type breeds. The producers keep improved exotic breeds of chicken or their crosses with indigenous breeds. Small-scale commercial poultry farms are commonly found in urban and peri-urban and obtain most of their feed and foundation stock from large-scale commercial farms (Mekelle, kombelcha ,Genesis, Alema etc) (Nzietchueng, 2008).

2.2.2. 2. Large-Scale Commercial Poultry Production

The large-scale commercial system (intensive production system) is the dominant production system in developed countries, and this sector has also recently expanded in many developing countries. According to (FAO, 2009) it is a highly intensive production system that involves, an average, greater or equal to 10,000 birds kept under indoor conditions and often including production of great grandparent flocks, with a medium to high bio-security level. The existence of somehow better bio-security practices has reduced chick mortality rates to merely 5% (Bush, 2006).This system heavily depends on imported exotic breeds that require intensive inputs such as feed, housing, health, and modern management system. This system is characterized by higher level of productivity where poultry production is entirely market-oriented to meet the large poultry demand in major cities with the main objective of production is to get better profit. In Ethiopia, ELFORA, Alema, and Genesis farms are the major large-scale poultry enterprises found in DebreZeiti. ELFORA is the largest enterprise, supplies about 420,000 chicken and over34million eggs per annum to the urban markets in the capital city (Wossene, 2006). According to (Wossene, 2006) Alema farm is the second largest poultry enterprise delivering about 500,000 broilers per annum to the Addis Ababa market. Alema farm has its own parent broiler stock from Holland; feed processing plant, hatchery, on-site slaughtering facilities and cold storage rooms as well as its own transport facility.(Bush, 2006) pointed Genesis farm is the third most important private poultry enterprise operating on average between 10,000 to 12,000 layers and has its own parent layer stock and hatchery. Large scale commercial poultry production systems are characterized by large vertically integrated production units and use high-producing modern strains of birds. In these systems, feed is the most important variable cost component, accounting for 65 to 70% of production costs (FAO, 2013). High productivity and efficiency depend on feeding nutritionally balanced feeds that are formulated to meet the birds' nutritional requirements.

2.3. **Feed Resources for Village Poultry Production**

Feed resources can be described as materials, which after ingestion by the animals are capable of being digested, absorbed and utilized. According to (Dessie and Ogle, 2001),the largest proportion of village chicken feed is the free range SFRB supplemented by household wastes. According to (Tadelle, 1996), the main feed sources for the village chicken in Ethiopia is scavenging including house wastes, cereals and their by-products, pulses, roots and tubers, oilseeds and shrubs. According to (Dessie and Ogle, 1996) and (Dessie and Ogle, 2000), scavenging feed resources of backyard poultry comprises of seeds, plant materials, worms insects and unidentified materials which are found around the home. According to (Tadelle *et al*., 2003), the feed resources for village chicken were very variable, and depending on the season, agricultural activities and rainfall. Scavenging feed resources are found to be much lower in protein (11.4%) and slightly lower in energy (2776 kcal ME/kg DM) (Rashid, 2003). According to (Dessie and Ogle, 2000),the protein content of the feed was higher in the rainy season than the dry season.(Rashid, 2003) reported that protein supplementation is more essential than energy in the scavenging poultry production systems. The nutritional status of laying village hens satisfy maintenance needs only and production of about 40 eggs/hen per year (Dessie and Ogle, 2000).The feed that the local chicken consume from scavenging is critically deficient in CP, Ca and P (Tegene, 1992). The feed offered by almost all rural poultry producers are incomplete, unbalanced and inadequate. Therefore provision of different energy and protein feed resources to the farmer managed birds enhance production performance of the chicken.

2.4. Commercial Poultry Feed Resources

The processed poultry feed comprising of mainly cereal grains, cereal grain by-products and oil seedcakes are available from feed mills that are largely concentrated in and around the capital city of Ethiopia (Solomon, 2008).

Energy concentrates: Contains < 20% CP) used in poultry diets primarily consist of cereals and their by-products. Maize is the most common energy feed fed to poultry worldwide because of its readily available source of energy and free of anti-nutritional factors (Leeson *et al*., 1997). Substantial amounts of sorghum, wheat, barley, and industrial by-products (wheat bran) are also used in poultry diets when price and supply allow for their inclusion.

Oilseed meals: are the protein-rich residues remaining after removal of most of the oil from oil-bearing seeds. In Ethiopia Noug (*Guizotia abyssinica*) seed meal contained the highest crude fiber (CF) and the least ME (Alemu and Guenther, 1992). Niger oil cake is a valuable source of protein, with a CP content varying between 22 and 42% of DM (Heuzé *et al.*, 2016).The oil content of most of these residues is relatively high due to the inefficient mechanism of oil extraction practiced in Ethiopia (Solomon, 1992). (Alemu and Tadelle, 1997) pointed Noug cake, a widely available high protein meal residue obtained after extraction of the oil which is a potential source of protein for poultry ration. Superior performance in terms of egg production was achieved with 21% Noug seed cake in the ration of layers (Maaza, 1981). According to (FAO, 2013) report sesame meal good source of methionine can be used at up to 15% in poultry ration. Sesame meal is one of the byproducts available in Northwestern Zone of Tigray region and its chemical composition varies depending on the method of processing and reported DM content ranges 83-96% while CP, ash, EE, NFE, and CF are 23-46%, 7.5-17%, 1.4-27%, 25-32%, and 5-12%, respectively (FAO, 1990). Oil seed cakes (sesame, groundnut, cotton, linseed, nouge, mustard etc) are brought from Bahrdar and sold at high cost.

Non-conventional feed resources (NCFR):- are referred as those feeds that have not been traditionally used in animal feeding and or not normally used in commercially produced ration for livestock (Devendra, 1985). The NCFR are described as those that are produced from production and consumption of crops and animals like agro-industrial by products of animals and plants origins which are inexpensively available.

2.5. Nutritional Constraints of Poultry Production

In Ethiopia poultry feed availability, quality and cost of feed is the major constraints for poultry production under both the rural small holder and large-scale systems (Yitbarek and Atalel, 2013). There is shortage of commercial feed resources and processing meals thought it is expensive. In Tigray region there is no any oil factory that can potentially supply oil seed cakes for animal farming except the village small mills or family base oil seed processing. The less availability, high transportation cost, and high price make the utilization of oil seed cakes to be very low especially under the smallholder farmers. To purchase formulated feed, it is high cost and there is transportation expenditure and the ingredients and processed feeds vary in nutritive value and there is no regular quality control mechanism in the country.

2.6. Nutrient Requirement of Poultry Chicken

Nutrient requirement is defined as feeding program to supply a range of balanced diets which satisfy the chicken at all stages of their development and which optimize efficiency and profitability. Energy, protein, lipids, mineral, vitamins and water are the main nutrients required by chicken, similar to other animals.

The nutrients required by birds vary according to species, age and the purpose of production that is whether the birds are kept for meat or egg production. The protein and energy supplied from SFRB as determined from chemical analysis of crop contents of scavenging local hens was an average 8.8% and 2864 kcal/kg respectively (Dessie and Ogle, 2000). The nutrient requirements are the values considered necessary for maintenance, optimum production, and prevention of any signs of nutritional deficiency. All growing animals including chicken need protein for maintenance and growth. Energy feeds are the most important feeds to maintain body temperature, exercise levels of the chicken, for maintenance, walking, feed searching, to trap insects, to protect from predator, for growth and production .Minerals are important for bone and eggshell formation, to develop strong bone and muscle, for blood circulation and to produce good feather. The most important minerals are calcium and phosphorous. Scavenging birds have far greater opportunity to balance their own micronutrient requirements. In the scavenging situation, minerals and vitamins are often provided from organic and nonorganic materials pecked from the environment by the birds.

2.6.1. Energy Requirement for Layers

The energy level in the diet of poultry is a major determinant for feed intake. Birds eat primarily to satisfy their energy needs. High productivity, modern poultry strains are typically fed relatively high-energy diets (FAO, 2013). The dietary energy level is often used as the starting point in the formulation of practical diets for poultry. According to (FAO, 2009) report normally, poultry diet consists of at least ¾ energy feeds. Energy feeds are the most important nutrient to maintain body temperature and exercise levels of the birds. The term used for the assessment of energy for poultry is Metabolisable energy (ME). The term refers to that portion of the feed which is available to the bird for the production of meat and eggs and for the maintenance of vital functions and of body temperature. The energy content of the diet must be considered in formulating a ration to meet the desired intake of all the essential nutrients other than the energy itself, including the intake of the essential amino acids throughout the laying cycle, daily energy requirements for maintenance and egg production vary because of variations in live weight and daily egg output. The total energy requirement in the period from the peak of production (28th week) up to 60 weeks of age (230 days) energy requirement/hen are about 1.5 MJ. This shows that, under conditions of constant environmental temperature, energy requirements do not vary significantly (Wethli, 1986).

2.6.2. Protein Requirement for Layers

Protein is needed for maintenance, muscle growth, synthesis of egg protein, for keeping up a good health status and to grow feather, etc. (FAO, 2009) pointed no more than 1/5 of a diet is protein-rich feeds, as they are normally very expensive. Chicken cannot synthesize amino acids rather they are 100 percent depends on feed for protein. The protein requirement of high producing laying hens varies from 16-18% of the diet, to meet the needs of egg production, maintenance and growth of body tissues (Dessie, 1997). Out of the total protein required by layers, relatively a small amount is used for maintenance while the rest is used for production purpose. To obtain high egg production, the required essential amino acids and total nitrogen which permits the synthesis of non essential amino acids in the body must be present in the ration of laying hens (North and Bell, 1984). The essential amino acids for poultry are lysine, methionine, threonine, tryptophan, isoleucine, leucine, histidine, valine, phenylalanine and arginine. Out of the ten essential amino acids, lysine, methionine and threonine are the most limiting in most practical poultry diets. The amino acid requirements of poultry are influenced by several factors, including production level, genotype, sex, physiological status, environment and health status. High levels of egg output or feather growth require relatively high levels of methionine. Chickpea, lentil, cowpea and green pea Legumes have better suppliers of mineral matter, particularly potassium, phosphorus, calcium, copper, iron, and zinc and also rich in lysine, leucine and arginine (Iqbal *et al*., 2006) . The variation in protein requirements may be due to differences in breed, environmental conditions and also due to differences in age, egg production and egg weight among birds and energy contents of the diets (Leeson *et al*., 1997).

2.6.3. Vitamin Requirement

Vitamins are important for different purposes such as for disease prevention, to produce strong and healthy chicken and to motivate different chemical changes that take place in their body. Vitamins are classified as fat-soluble (vitamins A, D, E and K) and water-soluble (vitamin B complex and vitamin C). All vitamins, except for vitamin C, must be provided in the diet. Vitamin C is not generally classified as a dietary essential as it can be synthesized by the bird. Natural vitamins are found in young and green plants, seeds and insects. Scavenging birds get vitamins by eating green grass, vegetables and fresh cow dung through sunlight and not needed additional vitamins for scavenging poultry but confined birds always need additional vitamins mixed into their feeds that provided as amino vitamin with water. This amino vit include multivitamin, electrolyte and amino acids, which improves egg production and egg quality, prevent diseases caused by vitamin deficiency and increase body resistance against diseases. Vitamins play a vital role in enzyme systems and natural diseases resistance of poultry. They are needed in very small quantities, but very essential to sustain life. Vitamins A, B2, and D3 are considered very important because many problems arise when birds lack these vitamins. Vitamin deficiency can lead to serious body disorders of chicks. In commercial poultry production, most vitamins can be purchased in a synthetic form and added to feed as a premix.

2.6.4. Mineral Requirement

Minerals are the inorganic parts of feeds or tissues and are needed for formation of the skeletal system, eggshell formation, for general health, as components of general metabolic activity, and for maintenance of the body's acid-base balance. Calcium and phosphorus are the most abundant mineral elements in the body, and are classified as macro-minerals. Calcium and phosphorus are necessary for the formation and maintenance of the skeletal structure and for good egg-shell quality. It is useful to know the proportion of each element in these compounds, so that the correct amounts of this element have to add to the diet.(Sonaiya and Swan, 2004) pointed out for growing birds, the ratio of Ca: P should be between 1:1 and 2:1. However, laying birds need a ratio of up to 6:1, and they need about 4 g of calcium per day for eggshell formation. (FAO ,2013) pointed a ratio of 2:1 must be maintained between calcium and non-phytate phosphorus in growing birds' diets, to optimize the absorption of these two minerals and the ratio in laying birds' diets is 13:1, because of the very high requirement for calcium for good shell quality. (FAO, 2009) evaluated laying hens need free access to calcium (limestone or crushed shells). Poultry's calcium and phosphorus requirements are influenced by the amount of vitamin D in the diet, and increased as the level of vitamin D decreased and vice versa. To be effective, their dietary levels must each be within acceptable ranges, not deficient and not excessive.

2.7. Importance of Supplementation

Definition of Supplementation: is feed or mix of feed ingredients high in one or more of protein, energy, minerals, vitamins and/or feed additives intended to be fed in limited amounts to support optimum performance. Chicken ration should be formulated to give the correct balance of energy, Protein and amino acids, minerals, vitamins and essential fatty acids. Supplementing the available SFRB with protein and energy source industrial by product feeds and minerals can improve the overall quality of the nutrition of the flock and increases the performance birds. (Tadelle, 1996) reported that egg production of local hens increased by 16% as a result of supplementing 15g maize and 15 gram Noug *(G. abyssinica*) cake/bird/day in the short rainy and dry seasons in the rural households. Scavenging White Leghorn layers offered 90g/hen/day of a commercial layer ration produced 200eggs/hen/year (Dessie, 1997). When pullets begin lying, there is an increase in protein, vitamin and mineral requirements per day due to deposition in the egg; indicating, there is a potential for improvement in the village systems by feed supplementation.

2.8. Feed Intake of Laying Hens

Feed consumption is a variable phenomenon and is influenced by several factors such as strain of the bird, ambient temperature, and density of birds in the shed, hygienic conditions, rearing environment, feed restriction, and feed characteristics. Poultry eat a daily amount of feed approximately 5% of their bodyweight (Rose, 1997). Feed intake of layers can be increased through providing feed at the proper time of the day mostly in the cool hours of the day – early morning and late evening in tropics (Jesuyon, 2016). Feed intake is increased as the energy value of the diet decreased and the fiber content of the diet increased (Uchegbu *et al.,* 2013). Feed intake is influenced by the amount of energy present in the diet (Harms *et al*., 1998).When feed quality and house temperature are maintained constant, an increase density of birds increased feed intake/dozen of eggs by 68 g/bird (Adams and Craig, 1985). For optimum production water is important for feed metabolism in the body. In moderate environmental temperatures, high producing white leghorn hens require 300-320 Kcal of Metabolisable energy per hen per day.

(Tadelle, 1996) and (Leeson and Summers, 2001) have reported that daily consumption of 17 or 18 g protein supported optimum egg production and egg size. Layers can adjust their feed consumption in order to obtain adequate energy when receiving diets ranging in energy from approximately 2500 to 3300 kcal ME per kg of diet. Rapid growth and early maturity is not desired in layer chicken (Maaza, 1981).

2.9. Body Weight Change of Chicken

Body weight of chicken is affected by non genetic factors like supplementary feeding, watering and health care (Tadesse *et al.*, 2013) and (Ali, 2002). (Tadesse *et al*., 2013) indicated that the adult female body weights of IB, BB and PK chicken under village production system were found 1.54, 1.55 and1.64 kg, respectively and statistically, no significantly differed. . The reduction in body weight gain is believed to be a direct result of reduced calorie intake (Chatterjee *et al*., 2007).

2.10. Feed Conversion Efficiency

Feed conversion efficiency (FCE): is a measure of efficiency of an animal in converting feed mass into the desired output. Therefore; feed efficiency in this study measures how the birds convert the feed in to egg production. Poultry has high feed conversion efficiency as compared to other animals. Such behavior also depends on type of the chicken. Broilers are fast growing and are efficient in feed conversion into meat, they need both high energy and protein feeds. Thus, they are encouraged to eat more feed. However, layers are slow growing and have high feed conversion efficiency to produce more egg rather than meat. Feed conversion ratio was identified as the major trait in egg production (Farooq *et al*., 2002).

2.11. Egg production performance of Chicken

When evaluating laying hen performance, egg production is one of the most important parameter. Egg production can be affected by factors such as feed consumption (quality and quantity), water intake, intensity and duration of light received, parasite infestation, disease, numerous management and environmental factors (Jacob *et al.*, 2000) . Free-range hen lay the first eggs at the age of 22-28 weeks and lay 3-4clutches of 10-15 eggs a year, depending on breed, health, development, season, and in particular availability of feeds (Riise *et al*., 2005). (Demeke, 2004) reported that the egg production performance of layers was linearly related to the level of supplements offered. Scavenging Koekoek and Bovans Brown both supplemented with 60g/day/bird layer commercial feed improved total collected egg by 6 and 25 eggs respectively in rural households (Derseh, 2017). In Ethiopia village farmers express a strong preference for brown feathered chicken because of their more productive (Dana *et al.*, 2010). (Tadesse, 2014) reported that the management level of the farmers may create difference in the production potential of the chicken. Thus, the effect of a feed ingredient is vital for hen-day egg production of the birds in the village systems.

2.12. Egg weight and Egg mass of Chicken

The weight of eggs varies widely depending on many factors such as the breed, weight of the bird, age of the layer and environmental temperature such as heat, stress and overcrowding. Egg weight is one of the important phenotypic traits that influence egg quality and reproductive fitness of the chicken (Islam *et al*., 2001) and (Farooq *et al*., 2001).When laying chicken ages, the egg weight increases due to body weight gain and reduces egg shell quality. (Flemming, 2005) reported that bigger eggs during late production has negative implications for egg quality and handling because of poorer hatchability, poorer shell quality and increased number of cracks. Egg weight influences the weight of components of eggs especially egg albumen and yolk. Egg weight is moderately heritable (Pradeepta *al*, 2015). Egg quality traits were affected by production systems among others. Egg weight of BB was the highest (62.53 g) in the cage system, followed by the free-range system (58.14 g) and the lowest (54.02 g) in the family type system (Yenice *et al*., 2016). (Tadesse *et al.*, 2015) pointed out average egg weight (g) of IB, BB and PK layer chicken under intensive and village production system were measured (64.78, 58.9);(63.46 , 59.32) and (47.79 , 47.53) respectively.

2.13. Morbidity and Mortality of Chicken

Poorly managed birds may get ill and grow slowly, producing fewer eggs and less meat. Birds that move everywhere may easily catch and spread diseases. Birds are seldom put in an enclosure or a shelter to protect them from wind and rain, or to keep them safe from predators and thieves and also do not get enough water, or they get dirty water, which may transfer diseases. (Tadelle *et al.*, 2003) evaluated that disease periodically decimates flocks and consequently more than 50% of the eggs produced were incubated in order to replace birds that have died. According to (Riise *et al*., 2005), diseases with high mortality (more than 30% of the flock) are Newcastle Disease(High mortality, often between 30% and 80% of the birds die) when the disease hits. The major causes of death of chicken are seasonal outbreaks of Newcastle disease and predation (Abebe, 1992). Avian Influenza and Fowl pox are highly contagious and difficult to treatment. Feed deficiency and malnutrition weakened the birds and made them more vulnerable to predators and also increased their susceptibility to disease. Mycotoxicosis (fungal poisoning) is a nutritional disease that causes feather loss and leg deformation. According to (solomon, 2008) during the dry season birds travel longer distances to find feed and made them more vulnerable to predators and resulted in contact with other flocks, which facilitated the transmission of disease. According to (Tadesse, 2014),evaluation in both midland (Adwa) and lowland (Rama) agro ecology of Tigray, high chicken mortality has always occurred at time of disease outbreak and predators. The exotic breed chicken are appreciated by the rural farmers for their more egg production but sensitive to disease, predators and feed shortage (Tadesse, 2014). Smallholder poultry farmers have faced different challenges, among which disease, feed and predator problems are the most (Yirgu *et al*., 2017). Therefore to produce well and have good resistance against diseases, birds need adequate quantities of good quality feed, clean water, housing and health control daily.

2.14. Egg Quality Parameters

Egg quality is a general term which refers to several standards which define both internal and external quality. The overall quality of an egg can be grouped under two broad categories namely external and internal (Monira *et a*l., 2003). The external quality of the egg is determined by features such as the size and shape of the egg as well as the structure, thickness and strength of the shell (Bain, 2005). Egg traits in poultry include egg number, egg weight, egg length, egg width, egg index, shell weight, shell thickness, age at sexual maturity and internal egg quality - Hough unit, albumin height, albumen weight, yolk colour, yolk diameter, yolk weight, yolk height, yolk index (Ojedapo *et al*., 2008). External quality is focused on shell cleanliness, texture and shape, whereas internal quality refers to egg white (albumen) cleanliness and viscosity, size of the air cell, yolk shape and yolk strength. Internal egg quality is affected by disease, egg age, temperature, humidity, handling, and storage.(Monira et al., 2003) pointed out the size and shape of avian eggs differs among the various species of birds, but all eggs have three main parts, yolk, albumen, and shell. These three parts of the egg are separated from each other by membranes. (Ojedapo *et a*l., 2008).The shell is separated from the albumen (egg white) by the shell membranes, and the yolk is separated from the albumen by the yolk membrane (vitelline membrane). Each component in egg has diverse roles for specific function and has their own proportion in whole eggs. The domestic fowl's egg contains about 64% of albumen, 27% of yolk and 9% of shell. The chalazae (0.25%) of the total egg weight are usually included with albumen weight. Shell membrane (0.75%) of the total egg weight is generally included with shell weight (Roberts, 2010). Embryonic development of hen's egg is dependent on traits like egg weight, yolk and albumen weights, genetic line and age of the hen (Onagbesan *et al.*, 2007).

2.14.1. Egg size

Egg size is an external trait affected by factors such as maturity weight, age of flock, ·breed / genotype, diseases, nutrition and level of feeding. The increase in egg size with age is a result of increase in the yolk size, albumen and shell weight, although these increases are not proportional (Fikru *et al*., 1996). Egg size can be also affected by nutrition, the intake of protein, specific amino acids such as methionine and cystine, energy, total fat and the essential fatty acids, linoleic acid. Increasing levels of these nutrients will improve early egg size and decreasing levels of these nutrients will control the size of eggs late in the cycle (Kellems and Church, 2002).

2.14.2. Egg shell quality

Egg shell is an external trait and very important structure component of egg since it serves to carry its contents to the consumer without cracking under normal handling conditions. It serve as gas exchange medium, prevent contamination by bacteria, and provide mechanical protection of the content and it is unique package for a valuable food (Shi *et al*., 2009). Shell quality is determined by shell deformities, shell thickness , shell weight, egg specific gravity, shell strength, resistance to breakage, texture, color, etc. (Sabri *et al*., 1999). Chicken rearing systems affects egg quality characteristics. (Yenice *et al*., 2016) pointed out eggshell thickness (mm) of BB for the cage and free-range systems were similar (0.39) and greater than those for the family type system (0.35).Egg shell thickness in (mm) was higher in grass pasture (0.58) and legume pasture (0.47) than in deep litter (0.38) at 60 weeks aged ISA Brown layers (Oke *et al.*, 2014).The eggshell thickness is an important trait for hatchability. For best result of hatchability egg shell thickness should be between 0.33 and 0.35 mm and few eggs with a shell thickness less than 0.27mm was hatched (Khan *et al.*, 2002). Marketability of eggs entirely depends on egg shell thickness and strength as poor egg shell quality in millions of dollars of loss in USA (Roland, 1988). According (Pradeepta *et al*, 2015) report egg shell thickness of at least 0.33 mm was necessary for the eggs to have at least a 50% chance to stand without breakage under normal handling condition. The shell thickness and porosity help to regulate the exchange of carbon dioxide and oxygen between the developing embryo and the air during incubation (Roque and Soares, 1994) . One of the main concerns is a decrease in eggshell quality as the hen ages, due to an increase in egg weight without an increase in the amount of calcium carbonate deposited in the shells. Egg quality characteristics are affected by genotype and age (Zita *et al*., 2009). (Pradeepta *et al*, 2015) was found eggs collected from 40 weeks aged White Leghorn hens have optimum egg weight (57.78

g), and shell characteristics (6 g, 0.32 mm). The quality of eggs depends on physical make up and chemical composition of its constituent parts (Chukwuka *et al*., 2011). According to (Tadesse *et al*., 2013) the difference in eggshell thickness was due to layer strain difference and (Zita *et al*., 2009) reported that difference in eggshell thickness was the effect of layer type difference, environmental conditions and feed quality.

2.14.3. Egg albumen quality

The albumen constitutes 60% of the egg weight, and 12% of the albumen is solids, 10.2% is protein, 1.0% is carbohydrate and 0.68% ash (Froning, 1998). The albumin quality is determined by Hough unit. The Hough Unit (HU) proposed by (Haugh, 1937) which is a measure of egg protein quality based on the height of its egg white (inner thick albumen) and the weight of an egg. The higher HU the number, the better the quality of the egg (fresher, higher quality eggs have thicker whites). According (Pradeepta *et al*, 2015) report White Leghorn have optimum egg weight (57.78 g with albumen height (8.41) mm and H.U. (92.00) were attributable to the freshness of eggs and proper age of hens. (Roberts, 2010) reported that albumen quality is influenced by many factors such as storage time , temperature, environmental conditions , hen age, strain of bird and nutrition (dietary protein and amino acid content) .

2.14.4. Egg yolk quality

The yolk is formed in the ovary during the final 10-12 days prior to the laying of the egg. According (Jacob *et al*., 2000) report egg yolk serves as a food sources for embryonic development. Yolk colour is one of the main criteria by which consumers judge the quality of eggs (Okeudo *et al*., 2003). (Okeudo *et al*., 2003) reported that consumer preferences for yolk colour are highly subjective and vary widely from country to country. However, the color of the yolk does not affect the nutritional content of the egg (FAO, 2003).Yolk colour was estimated by visual evaluation method using La Roche scale (Bovšková *et al*., 2014). Egg yolk from a newly laid egg is round and firm (Okoli and Udedibie, 2000). As the egg gets older, the yolk absorbs water from the egg white, increasing its size and the vitelline membrane becomes weak as a result the yolk looks fl at and shows spots. Yolk colour is a function of feed not breeds (Demeke, 2004) and (Altamirano, 2005). (Yenice *et al.*, 2016) evaluated that yolk colour of BB eggs obtained from the family type system was superior (11.85) to that obtained from the cage (10.36) and free-range systems (10.42).The determinant of yolk color is the xanthophylls (plant pigment) content of the diet consumed (Silversides et al., 2006). (Bovšková *et al*., 2014) reported that free range eggs are extra yellow in colors because of high content of carotenoids in the eggs compared to home hen breeding. According (Ali, 2002) the darker yellow colour in scavenging birds than intensive condition was due to the access of these birds to natural sources of feed. Among feed ingredients, only supplemented yellow maize contributes to improved color intensity of the yolk (Altamirano, 2005). (Tadelle *et al*., 2003) reported that Small sized eggs from the scavenging local chicken with deep yellow yolk color fetch much higher prices compared to larger eggs of improved strains with pale yolk. The premium for local birds is attributed to better meat flavor and more deeply colored egg yolks (Dessie and Ogle, 2001). However, at village level, significant difference in egg yolk colour may not be expected between local and exotic chicken (Tadesse, 2012).

2.15. **Poultry Economics**

Feed costs are the major costs that influenced the profitability of chicken rearing (Geleta and Leta,2015). Feed alone may contribute from 60 to70% to the total cost of production in egg type layers (Qunaibet *et al*., 1992). Feed cost accounts for about 60-70% of poultry production depending on the geographical location, season and country (Wilson and Beyer, 2000). Better utilization of feed and reducing unnecessary feed wastage could be the leading factors in minimizing total cost of production (Elwardany *et al*., 1998). According to (Moges *et al*., 2014) market accessibility affects the egg price, farmers who sell their eggs in urban market got better price than rural market. Moreover (Moges *et al*., 2014) reported supplementation of scavenging poultry with Nouge seed oil cake was found to be technically and economically beneficial, especially in the dry season .

CHAPTER 3: MATERIALS AND METHODS

3.1. Description of the Study Area

The study was conducted in Northern Ethiopia central zone of Tigray Region, Adwa district in kebele Enda mariam shewito which is found 225 km far from Mekelle and 1006 km from Addis Abeba which is the capital city of Ethiopia. Geographically, it is bounded between 529383-534336m longitude and 1544367-1554478 m latitude at an altitude of 1650-2300 meter above sea level with total area of 38.06Km^2 in midland agro-ecology.

The livestock population of the Wereda includes 45002cattle, 96409 goats, 54031sheep, 13184equines and 192770 poultry chicken (AOoARD, 2016).

The minimum and maximum rainfall of the area is 600-850 mm and the mean annual temperature is 27^{0}C. The main economic activities of the study areas are mixed crop-livestock farming which being practiced by the small holder farmers (crop cultivation and livestock rearing). The dominant crops produced in the study focus area are Barely, *Hanfets* mixture of barley and wheat, teff, millet and maize.

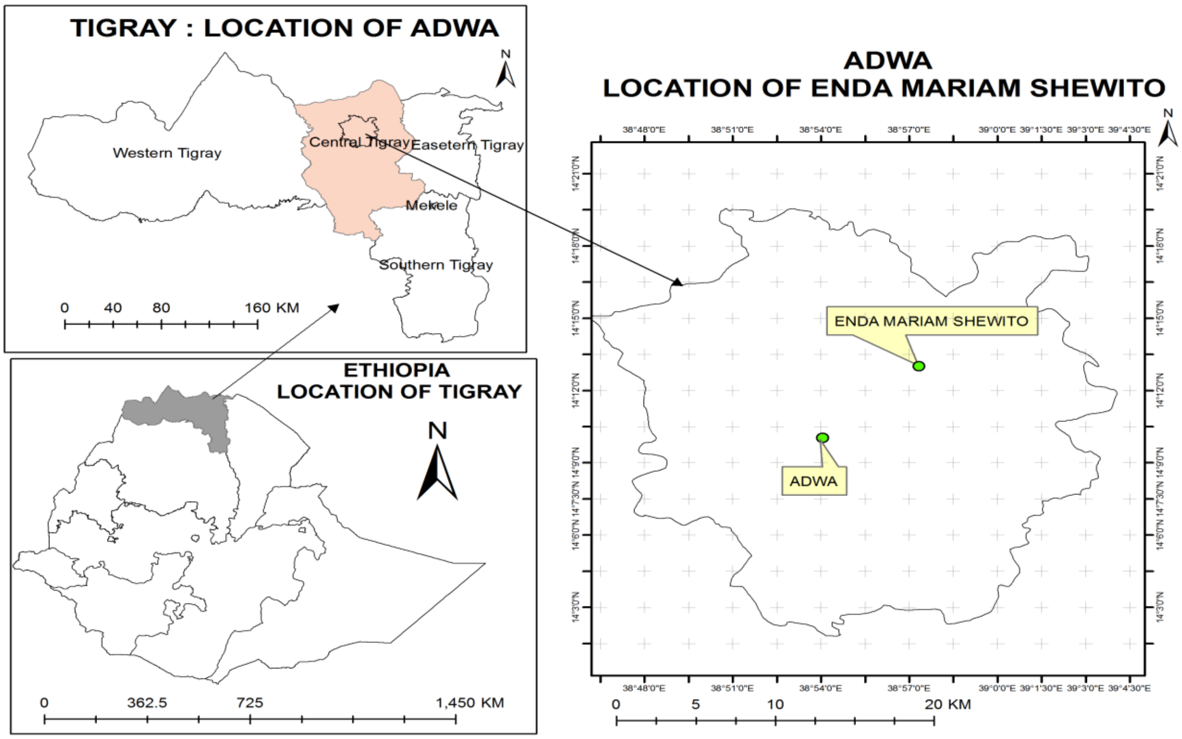


Figure 1. Map of the study area (Northern Ethiopia, central zone of Tigray, Adwa district)

3.2. Characteristics of Targeted Households

The household characteristics of these targeted farmers for this study were all male headed households with average age of 37.5 years and their educational status were literate ranging from grade 5th to grade 8th. The average family sizes per household were 5.5. The average land holding of these farmers per household was 0.625 hectare and they were practiced livestock production, crop production and irrigation activities. The targeted farmers were given training on how to feeding, watering, housing and disease control of the birds and how to collect the relevant data.

3.3. Experimental Design and Treatments

The present study was conducted using one hundred Bovans brown layers with six months age were used as experimental units. The birds were randomly allocated into 4 treatments. Each treatment was comprised 25 birds and each treatment group was further subdivided into 5 replicates and each replication was comprised 5 birds. Totally in 4 treatments there are 20 replications. The numbers of replications are the number of targeted farmers. Randomized complete block Design (RCBD) was used. The blocking factor was the management difference among the farmers. On the village where the research site was selected, group discussion was under taken to identify the target farmers. The selection criteria of the farmers were based on similar economic status, educational status, landholding, house hold headed. Based on the information the study was carried out in twenty systematically selected literate male headed households with land holding and bellow bench mark economic status that is (with daily income bellow one US dollar per head) .

Table1. Layout of the experiment

Treatment	No of Replications	Number of birds per replication or farmer				
		R_1	R_2	R_3	R_4	R_5
T1: no supplement/farmer managed only/	5	5	5	5	5	5
T2: farmer managed +7% Nouge cake + 14.5% maize grain+ 7% limestone+ 0.5% salt	5	5	5	5	5	5
T3: farmer managed+ 7% sesame meal + 10% maize grain+7% limestone+ 0.5% salt	5	5	5	5	5	5
T4 : farmer managed +4% sesame meal +4% Nouge cake+ 10 %maize +7% limestone+ 0.5% salt	5	5	5	5	5	5

3. 4. Experimental Feed Ingredients

The locally available feed resources (maize, nouge cake, sesame meal, limestone and salt) were used to formulate the experimental diets. The feed resource are available in Adwa but for purity Sesame meal was purchased from shire (Adidaero), Nouge cake from Mekelle where as maize; limestone and salt were purchased from Adigrat market for easy of collection and preparation but also available in Adwa. All these feeds were run through hummer mill and broken to 5 mm sieve size before use in the ration and was mixed based on the treatments needed to fulfill the nutritional gab of the layers.

3.5. Chemical Composition of Ingredients and Experimental Rations

The nutritional compositions of each ingredients ,the dry matter(DM%), metabolized energy (ME (Kcal), crude protein (CP%), crude fat(%), crude fiber (CF%), calcium (Ca%) and Phosphorus (P %) used in the experiment to formulate the treatment diets were taken from pre –determined literatures presented in (Table 2).

Proportion of ingredients (%) used in formulating the experimental rations presented in Table 3 was created based the feed win to fill full the nutrient requirement of the layers by taking the feed ingredients (scavenging, nouge cake, maize grain, sesame meal, limestone and salt) .Scavenging was equally common for all birds in T1, T2, T3 andT4.

The nutritional compositions of dietary treatment rations presented in Table4 were developed from the result of the proportion of the ingredients inTable3 using the feed win. The three treatment rations (T2,T3and T4) in this study were formulated to be iso-caloric and iso-nitrogenous with 2750-2900kcal ME/kg DM and 16-17% CP to meet the nutrient requirements of layers (NRC, 1994) (Table 4).

Table2. Chemical composition of ingredients used in the ration (% on DM basis)

Chemical component	Raw material (Ingredients)					
	Scavenging	Sesame seed meal	Nouge seed cake	Maize grain	Limestone	Salt (NaCl)
DM%	91.1	93.3	93.3	86.9	99.00	95.00
ME (Kcal)	2245	2480	2293	3340	0.00	0.00
CP%	12.9	44.3	33.8	8.7	0.00	0.00
Lysine (gr)	-	1.11	1.18	0.22	0.00	0.00
M + C (gr)	-	2.17	1.37	0.35	0.00	0.00
Meth (gr)	-	1.24	0.67	0.20	0.00	0.00
Fat%	4.7	10.4	9.10	3.60	0.00	0.00
Fiber%	6.5	6.3	19.00	2.10	0.00	0.00
Ca%	1.05	1.68	0.90	0.04	38.00	0.00
P%	0.38	0.94	1.21	0.30	0.00	0.00

DM = Dry Matter; ME=Metabolized energy; CP = Crude protein; M+C= Methionine + cytosine Meth=Methionine; Ca=calcium ; P=phosphorus ;NaCl=Sodium chloride salt and gr=grain (very small unit of weight,1gr=0.0648gm) .

Source: (Yami, 1981); (FAO, 1990); (Alemu and Guenther, 1992); (Dessie and Ogle, 2000); (Rashid, 2003) and (Mekonnen *et al*., 2010).

Table3. Proportion of ingredients (%) used in formulating the experimental rations

Ingredient	T1	T2	T3	T4
Scavenging	√	√	√	√
Noug Seed Cake	0	7	0	4
Maize	0	14.5	10	10
Sesame meal	0	0	7	4
Limestone	0	7	7	7
Salt	0	0.5	0.5	0.5
Total	0	29	24.5	25.5

T= treatment

Table 4. Nutritional composition of dietary treatment rations

Chemical component	Treatments			
	T1	T2	T3	T4
DM (%)	91.1	91.62	91.58	91.9
CP (% DM)	12.9	16.58	16.87	16.79
EE (% DM)	4.7	5.88	5.79	5.84
CF (% DM)	6.5	8.15	7.15	7.72
P (% DM)	0.38	0.51	0.48	0.5
Ca (% DM)	1.05	3.78	3.83	3.82
Lysine(gr)	-	0.11	0.1	0.11
Meth(gr)	-	0.08	0.11	0.10
M+C(gr)	-	0.15	0.19	0.18
ME (kcal/kg DM)	2245	2909.51	2752	2769.92

DM = Dry Matter, CP = Crude protein; EE = Ether Extract; CF = Crude Fiber, P=phosphorus; Ca=calcium; Meth=Methionine ; M+C=Methionine + cytosine ME=Metabolized energy and gr=grain (very small unit of weight,1gr=0.0648gm) .

3.6. Management of Experimental Chicken

Mekelle poultry farm is the source of the experimental chicken. Adwa local chicken grower and distributor center were brought the chicken from Mekelle poultry farm when they were day-old chicken and maintained until the age of 45 days old with the ration obtained from chicken multiplication center; then distributed to the farmers and they kept until the chicken reach twenty four weeks age with their management. When the chicken starts first egg laying (25 weeks age old), additional concentrate feed was provided for 90 days experimental period and managed under the village chicken production systems /semi scavenging/production system with some inputs like housing, feeding, watering, vaccination and improved breeds (Bovans Brown) as listed below.

Poultry housing: The farmers have locally made poultry house which were separated from the people and other animals. The poultry houses were without litter but have perch and were cleaned mostly daily and few per two day. The farmers were kept only the experimental birds during the study period.

Poultry Feeds and feeding practices: The farmers gave some crops like maize, *Hanfets* (mixture of wheat and barley), millet, barley and sorghum during morning and evening to the birds. Moreover non-conventional feed resources such as Vegetable leftovers are used as supplements during the irrigation season and include cabbage, tomatoes and salads,. The hens most of their feed got from house left over and from the house surrounding by scavenging such as wastes, insects, grasses, sand and left over crops but not enough it was only for their body maintenance and few egg production as it was observed on the control group. The farmers have prepared different poultry feeding materials for the supplemental prepared ration. The daily allowance of the supplemental ration for birds in T2, T3 and T4 were 34.80gm, 29.40gm and 30.60gm per bird respectively. The prepared ration was offered to the hens twice per day early in the morning and late in the afternoon with full day scavenging. The birds offered the first time, at 6.30 am and the rest half of the feed for the second time, at 4.00 p.m. The experimental layers were allowed an adaptation period seven days for the feed before the commencement of data collection. The experiment was conducted for a period of 12 weeks from February 9/2017- May 8/2017 among rural farmers.

Poultry watering: The farmers have different poultry waterer materials and they gave to the hens clean water throughout the whole day and the waterer were cleaned daily.

Laying nest: The farmers have prepared laying box made from local materials found in some farmers inside the poultry house and also in some other farmers outside the poultry house. The laying boxes were found in dark area protected from disturbance by people and other animals.

Poultry health management: The chicken were vaccinated against Newcastle disease, gumburo disease and fowl typhoid during rearing period before the distribution of the birds to the targeted farmers.

3.7. Data Collection Procedures and Measurements

The amount of feed offered, feed refusal, the number of laid eggs and the number of dead and sick chicken was recorded daily; body weight of the layers at the starting and at the final of the study was measured; Egg quality characteristics (shell thickness, egg shell weights**.** albumen height albumen weight, Hough unit, yolk height, yolk weight, Yolk Index ,Yolk diameter and yolk color) were determined. Using these recorded data the following things were calculated as follows:

3.7.1. Feed intake

Feed intake and feed refusal was recorded daily from each replicate and the amount of feed consumed was determined by obtaining the difference between the quantity of feed offered and the quantity of feed remaining in the evening every day after the hens housed on DM basis. Daily feed offered and refusal was measured using electronic balance that can measure up to 200g capacity and it was calculated as follows:

- $$\text{DFI(DM)} = \frac{\text{DFO-DFR}}{\text{DFO}} \times 100 \text{-- Equation 1}$$

Where:D FI = Daily feed intake on dry matter base, DFO = Daily feed offered on dry matter base, DFR = Daily feed refusal on dry matter base.

3.7.2. Body weight change

The hens were weighed individually at the beginning and end of the experiment in the morning hours to obtain body weight change using the sensitive balance of 0.005-3 kg capacity and it was calculated as the difference between the final and initial body weight of the birds as follows:

BWC = Final live weight (kg) -Initial live weight (kg) ----------------------------- Equation2

- Average daily gain (g/d) was calculated as the difference between final and initial body weights divided by number of feeding days as follows
- $$\text{Av. daily gain (g /d)} = \frac{\text{Final live weight- Initial live weight}}{\text{Number of feeding days}} \text{-----------------------------Equation3}$$

3.7.3. Feed conversion efficiency

Feed conversion efficiency (FCE)**:** It explains the amount of gram egg per gram of feed consumed per replicate and it helps to know how the layers are efficient in converting the feed into egg .It was calculated by dividing daily grams of egg laid by daily grams of feed intake

$$\text{FCE\%} = \frac{\text{Daily egg weight (g)}}{\text{Daily feed consumed (g)}} \text{X100--Equation4}$$

Where: FCE (%) = Feed conversion efficiency in percentage, DLE (g/d) = Daily laid egg in Gram, DFI (g/d) = Daily feed intake on dry matter base in gram.

3.7.4. Egg production

Eggs was collected immediately after laid daily and weighed in the evening. Egg production was calculated on a hen-day and hen-housed bases.

- Hen-day egg production as percentage was determined following the method of(Hunt on, 1995) as follows:

$$\%HDEP = \frac{\text{Number of eggs collected per day}}{\text{Number of hens present on that day}} \times 100 \text{------------------------ Equation5}$$

- Hen-housed egg production as percentage was calculated as:

$$\%HHEP = \frac{\text{Number of eggs collected in the period}}{\text{Number of hens originally housed x no. of days}} \times 100 \text{----------------------------------- Equation6}$$

3.7.5. Egg weight and egg mass

Eggs were weighed in the evening after laying for each replicate daily using an electronic balance to the nearest 0.01 g that can measured up to 200 g and average egg weight was computed by dividing the total egg mass to the number of eggs. Egg mass per hen was calculated as total egg mass divided by number of hens.

$$\text{Egg mass (g/hen/day)} = \frac{\text{Total egg mass}}{\text{Number of hens}} \text{ ……………………………………………...…… Equation 7}$$

3.7.6. Morbidity and mortality of chicken

Morbidity and mortality percentage of chicken was calculated:

$$\text{Mortality percentage } \mathbf{(\%)} = \frac{\text{number of dead hens + number of culled hens}}{\text{Total number of hens}} \times 100 \text{---------Equation8}$$

$$\text{Cumulative morbidity percentage } \mathbf{(\%)} = \frac{\text{The total number of infected chicken}}{\text{The number of housed chicken}} \times 100 \text{----Equation9}$$

3.7.7. Egg quality parameters

Daily egg production records were kept starting from age of 26 weeks after the adaptation period to 38 weeks in lay. Egg quality parameters were determined six times during the study period by tacking egg samples which is three eggs from each replication per two week that is 30 eggs per treatment per month for egg quality characteristics analysis. The quality parameters investigated were include(shell thickness, egg shell weights**.** albumen height albumen weight, Hough unit, yolk height, yolk weight, yolk index, yolk diameter and yolk color).The eggs were weighed after collection and average egg weight of each group was determined.

3.7.7.1. Eggshell quality

The egg shell thickness without shell membrane was measured at three location of the egg (air cell, equator and sharp end) by micrometer gauge .The average of the three sites was taken as egg shell thickness. The egg shell weights were measured using electronic sensitive balance that can measured up to 200g capacity.

3.7.7.2. Egg albumen quality

The height of albumen was measured by using both ruler and vernier caliper. The weight of Albumen was calculated by the formula below as follow:

Albumen weight (AWT) = Egg weight- (Yolk weight + shell weight)………………Equation 10

Hough unit (HU) is one of the most significant measures of egg quality next to other measures such as eggshell thickness and eggshell strength and it shows the higher the Hough unit number, the better the quality of the egg (fresher, higher quality eggs have thicker whites) (Haugh, 1937). Hough unit (HU) was calculated using thick albumen height and egg weight using the formula suggested by Raymond Hough in 1937(Haugh, 1937):

$HU=100 \times \log (H-1.7W^{0.37}+7.6)$……………………………………………………Equation 11

Where HU = Hough unit, H = Albumen height and W = Egg weight

3.7.7.3. Egg yolk quality

After separation of the yolk from the albumen, yolk diameter was measured using venire caliper and yolk height was measured by using both ruler and venire caliper. The weight of the yolk was measured by electronic balance capacity from 0- 200g.

Yolk index was computed using the following formula:

$$\text{Yolk Index} = \frac{\text{Yolk height}}{\text{Yolk diameter}}$$ ……………………………………………………..… Equation 12

The **Roche Yolk Colour Fan** (RYCF) is widely accepted standard for measuring yolk colour and it has 1-15 strips of color from pale to orange yellow were used to measure the color of the yolk. During yolk color measurement, first the yolk membrane was removed, the whole yolk was thoroughly mixed and yolk sample was taken on a piece of white paper and compared with Roche fan measurement strips. The fan is important to define the desired yolk colour and helps us to formulate the hens' feed according the target yolk colour.

3.8. Partial Budget Analysis

Partial budget analysis was also applied in order to evaluate the profitability of feed supplementation on Bovans Brown layers under farmer's management condition. Partial budget analysis was employed using proper procedure (Upton, 1979). Current prices of the additional inputs feed cost and feed processing and mixing costs were considered in the analysis. Feed cost for transportation and Labor requirement for feeding hens was not considered. Each treatment feed cost was calculated by recording the cost of feed ingredient at purchase and the amount of feed consumed by the birds multiplied by the cost of the ingredients .The analysis was done by considering the current prices of eggs(i.e. 3 birr per egg) for calculation of total return .

NR = TR-TVC……………………………………………………………………….Equation 11

Where: NR = Net return, TR = Total return, TVC = Total variable cost

The change in net return was computed as:

ΔNR= ΔTR-ΔTVC…………………………………….…………………………Equation 12

Where: ΔNR = Change in net return, ΔTR = Change in total return, ΔTVC = Change in total variable cost.

The marginal rate of revenue quantifies the increase in net return associated with each additional unit of expenditure. This is expressed by percentage as:

$$MRR\ (\%) = \frac{\Delta NR}{\Delta TVC} X100 \qquad \text{Equation13}$$

Where: MRR (%) = Marginal rate of revenue in percentage, ΔNR= Change in net return, ΔTVC = Change in total variable cost.

3.9. Statistical Analysis

The data were analyzed using analysis of variance (ANOVA) that is one way-ANOVA and was subjected in Randomized Complete Block Design (RCBD) using the Statistical Analysis system (SAS) version 9.1.3 (SAS, 2008). Means differences in productive performances and egg quality traits were compared using Turkey's Standardized Range Test (HSD), and the significance was set at $P < 0.05$.The following statistical model was used for the study.

$$Yij = \mu + Ti + Rj + eij \qquad \text{Equation15}$$

Where Yij = response variable (i.e. feed intake, bodyweight gained, egg production, mortality morbidity ,egg quality and profitability) taken under treatment i.

μ = over all means

T_i = i^{th}treatment effect (feeds)

R_j= j^{th} replication effect (20-replication effect based on farmers management difference)

e_{ij} = is a random error

CHAPTER 4: RESULTS

4.1. Feed Intake of Supplemented Rations

Daily feed intake of layers is presented in Table 5. Dry matter feed intake was significantly affected by dietary proteins and dietary energies combinations ($P < 0.05$). Significant higher dry matter intakes was observed from the combination of feed with comparatively higher 16.87% CP and slightly lower 2752 kcal/kg ME that is in T3 than T2 and T4.

4.2. Body Weight Gain of the Chicken

The body weight parameters are presented in Table 5. The present result showed that body weight gain and average daily body weight gain was affected by feed supplementation. The Chicken in treatments (T2, T3 and T4) were scored significantly higher body weight gain and average daily body weight gain than non supplemented group (T1).

4.3. Egg Production Performance of Chicken

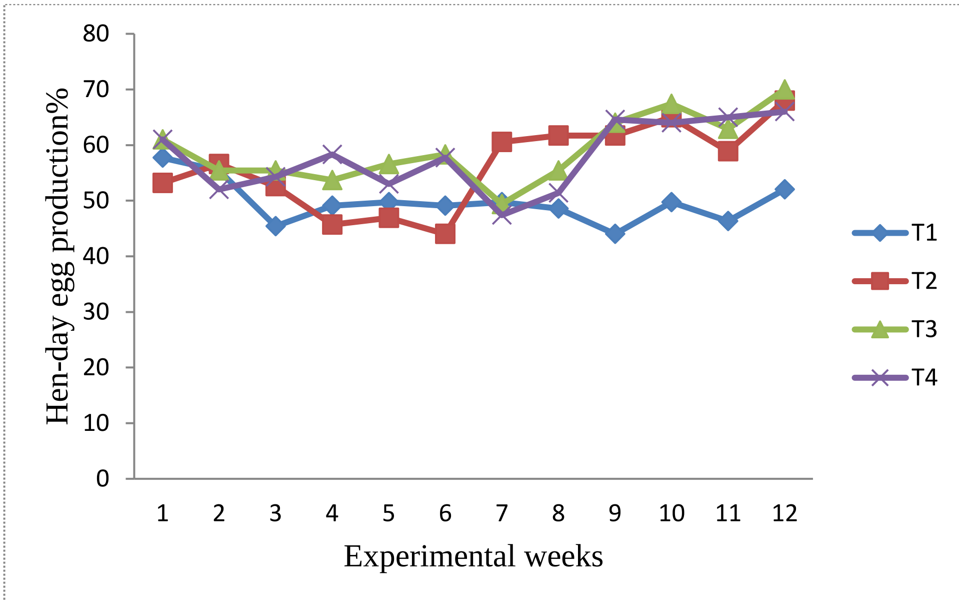
Feed supplementation is affected the production performance of layers and egg quality traits except Albumen weight, albumin height, Hough unit and yolk colour. Hen-day and hen-housed egg production separately increased from the non-supplemented group from week 7 onwards (Figure 2 and Figure 3).This might be due to the birds well adapted to the supplementary feed and increasing feed consumption .When the level of dietary protein and dietary energy of the diet increased, these nutrients improved the production performance and egg quality traits . Among the feed supplemented treatments, chicken in (T3) with 16.87% CP and 2752 kcal/kg ME diet scored comparatively the highest performance (Table 5).

Table 5. Dry matter intake, body weight gain and egg laying performance of farmer managed Bo vans Brown layers over a period of 26 to 38 weeks of age (N=25 birds/treatment).

Parameters	Treatments				
	T1	T2	T3	T4	P-value
DFI%	-	96.425^{c}	97.575^{a}	97.301^{b}	<.0001
Initial BW (g/bird)	1498	1496	1492	1493	0.7411
Final BW (g/bird)	1538	1552.8	1554	1554.8	0.8636
BW gain (g/bird)	32^{b}	56.8^{a}	62^{a}	61.6^{a}	0.0007
AD gain (g/bird)	0.3552^{b}	0.6302^{a}	0.6892^{a}	0.6846^{a}	0.0007
Total egg/hen	44.32^{d}	51.16^{c}	53.44^{a}	52.20^{b}	<.0001
HDEP (%)	49.244^{c}	56.668^{b}	60.356^{a}	58.740^{a}	<.0001
HHEP (%)	49.244^{c}	56.668^{b}	60.356^{a}	57.51^{b}	<.0001
Egg weight (g)	55.332^{b}	56.114^{a}	56.222^{a}	56.252^{a}	0.0001
EM (g/hen/day)	27.264^{c}	31.368^{b}	32.068^{a}	33.070^{a}	<.0001
FCE (g of eggs /g of feeds)	-	0.97^{b}	1.0956^{a}	1.0799^{a}	<.0001
Morbidity%	0	0	0	0	
Mortality (%)	0	0	0	8	0.4182

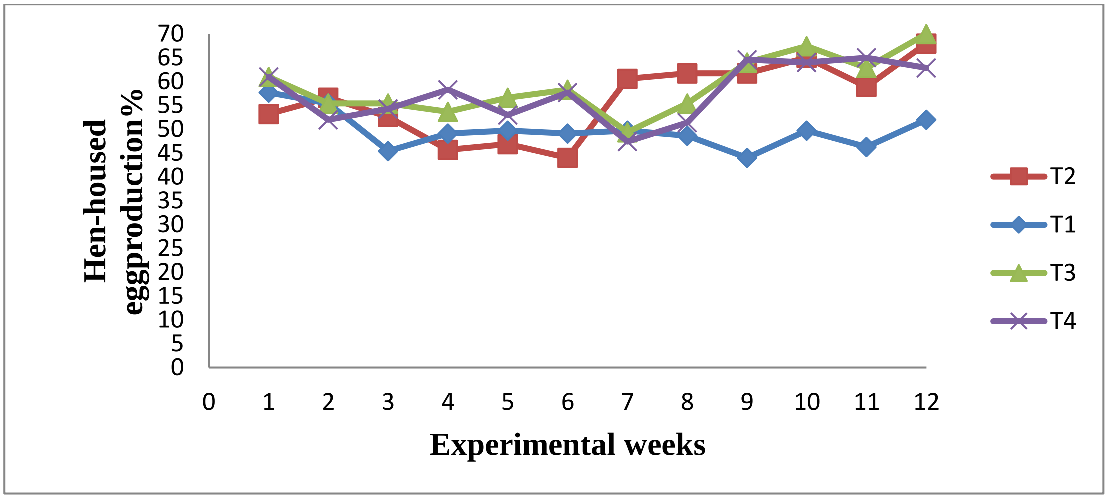
^{a,b} Means within a row with different superscripts are significantly different at ($P< 0.05$); DMI = dry matter intake; BW = body weight; ADG=average daily gain; HDEP = hen–day egg production; HHEP = hen-housed egg production; EM = egg mass; FCE=feed conversion efficiency; T1=no supplement/farmer managed only/; T2= farmer managed +7% Nouge cake + 14.5% maize grain+ 7% limestone+ 0.5% salt; T3 = farmer managed+ 7% sesame meal + 10% maize grain+7% limestone+ 0.5% salt and T4 = farmer managed +4% sesame meal +4% Nouge cake+ 10 %maize +7% limestone+ 0.5% salt.

Figure 2.Weekly average hen-day egg production of Bovans Brown layers fed on different locally available rations during the experimental period.



T1=no supplement/farmer managed only/; T2= farmer managed +7% Nouge cake + 14.5% maize grain+ 7% limestone+ 0.5% salt; T3 = farmer managed+ 7% sesame meal + 10% maize grain+7% limestone+ 0.5% salt and T4 = farmer managed +4% sesame meal +4% Nouge cake+ 10 %maize +7% limestone+ 0.5% salt.

Figure 3.Weekly average hen-housed egg production of Bovans brown layers during the experimental period.



T1=no supplement/farmer managed only/; T2= farmer managed +7% Nouge cake + 14.5% maize grain+ 7% limestone+ 0.5% salt; T3 = farmer managed+ 7% sesame meal + 10% maize grain+7% limestone+ 0.5% salt and T4 = farmer managed +4% sesame meal +4% Nouge cake+ 10 %maize +7% limestone+ 0.5% salt..

Table 6. Egg quality of farmer managed Bovans Brown layers fed on different locally available rations

Egg quality Parameters	Treatments				
	T1	T2	T3	T4	P-value
Sample egg weight(g)	56.106	57.298	57.688	57.632	0.3431
Shell thickness(mm)	0.368^{b}	0.388^{a}	0.398^{a}	0.386^{a}	0.0018
Shell weight(g)	4.908^{b}	5.312^{a}	5.354^{a}	5.350^{a}	0.0018
Albumen weight(g)	37.486	37.598	36.782	37.160	0.7361
Albumen height(mm)	8.040	8.068	7.996	8.052	0.9878
Hough unit	90.552	90.112	90.016	90.264	0.9483
Yolk weight(g)	13.062^{c}	13.786^{b}	14.920^{a}	14.472^{a}	<.0001
Yolk height(mm)	15.600^{b}	15.850^{b}	16.442^{a}	16.176^{a}	0.0042
Yolk diameter (cm)	3.766^{a}	3.712^{b}	3.816^{a}	3.696^{b}	0.0038
Yolk index	0.416^{b}	0.424^{b}	0.434^{a}	0.438^{a}	0.0087
Yolk colour(RSP*)	9.96	9.91	9.96	10.02	0.955

^{a,b} Mean within a row with different superscripts are significantly different at ($p<0.05$); *RSP = Roche Scale Points; T1=no supplement/farmer managed only/; T2= farmer managed +7% Nouge cake + 14.5% maize grain+ 7% limestone+ 0.5% salt; T3 = farmer managed+ 7% sesame meal + 10% maize grain+7% limestone+ 0.5% salt and T4 = farmer managed +4% sesame meal +4% Nouge cake+ 10 % maize +7% limestone+ 0.5% salt.

Table 7. Yolk color points of egg samples from different experimental diets

	Roche yolk color points					
Diets	8	9	10	11	12	Total
T1	8	26	24	28	4	90
T2	6	22	36	24	2	90
T3	8	24	32	14	12	90
T4	2	30	36	16	6	90
Total	24	102	128	82	24	360

RSP = Roche Scale Points (Roche yolk color points: 1 = light yellow; 15 = orange**;** T1=no supplement/farmer managed only/; T2= farmer managed +7% Nouge cake + 14.5% maize grain+ 7% limestone+ 0.5% salt; T3 = farmer managed+ 7% sesame meal + 10% maize grain+7% limestone+ 0.5% salt and T4 = farmer managed +4% sesame meal +4% Nouge cake+ 10 %maize +7% limestone+ 0.5% salt.

4.4. Partial budget Analysis

The partial budget analysis of the birds in T1, T2, T3 and T4 was calculated as 3324.00, 3385.68, 3499.00 and 3427.35 net return in Ethiopian birr respectively from sale of eggs within three months experimental period (Table 8). The result of the study indicated that net return increased as the level of dietary protein and dietary energy increased because these nutrients improved the production performance and egg quality traits of the hens .

Table 8. Partial budget analysis of farmer managed Bovans Brown layers fed on different locally available ration formulations

Variable	Treatments T1	T2	T3	T4
Total feed consumed (kg)	-	75.50	64.55	66.99
Total feed cost/ treatment (ETB)	-	427.00	476.19	458.87
Labor cost (for processing) (ETB)	-	24.32	32.81	28.78
TVC (ETB)	-	451.32	509.00	487.65
Total egg produced	1108	1279	1336	1305
Total return (TR)(ETB)	3324	3837	4008	3915
Net return (NR) (ETB)	3324	3385.68	3499.00	3427.35
∆TR (ETB)	-	513	684	591
∆TVC (ETB)	-	451.32	509	487.65
∆NR (ETB)	-	61.68	175	103.35
MRR(%)	-	13.67	34.38	21.19
Dozens of egg	92.33	106.58	111.33	108.75
Feed cost/dozen egg (ETB)	0	4.16	5.00	4.67
Egg sale/Feed cost ((ETB)	0	8.98	7.35	7.89

ETB = Ethiopian Birr; TVC= total variable cost; TR=total return; NR = net return; ∆TVC=change in total variable cost; ∆NR= change in net return; MRR%= Marginal rate of revenue in percentage; T1=no supplement/farmer managed only/; T2= farmer managed +7% Nouge cake + 14.5% maize grain+ 7% limestone+ 0.5% salt; T3 = farmer managed+ 7% sesame meal + 10% maize grain+7% limestone+ 0.5% salt and T4 = farmer managed +4% sesame meal +4% Nouge cake+ 10 %maize +7% limestone+ 0.5% salt.

CHAPTER 5: DISCUSSION

5.1. Feed Intake of Supplemented Rations

Dry matter feed intake was significantly affected by dietary proteins and dietary energies combinations (P <0.05). The current result shows, DFI % was found significantly higher in birds T3 than in birds of T2 andT4 (P< 0.0001). Higher dry matter intakes was observed from the combination of feed with comparatively higher 16.87% CP and slightly lower 2752 kcal/kg ME and the combination of this feed has most probably good palatability that increased the apatite of the chicken. The current finding agrees with (Almeida *et al.*, 2012) and (Geleta and Leta,2015) who found higher feed intake from using low energy and high protein combination diet compared to higher energy and low protein contents feed. Increasing dietary protein would increase feed intake to provide energy needed for increased egg production but as energy was increased in the diet, feed intake would decreased (DePersio, 2011).This probably was also related to the possibility of that, the palatability of the diet could be due to sesame meal has higher protein with less fiber content than nouge seed cake. This was consistent with (Moges *et al*., 2014) denoted that poor palatability of Niger seed cake by local scavenging hens.(Dawud *et al*., 2014) reported that higher levels of dietary Nouge seed cake depressed feed intake.

5.2. Body Weight Change of the Chicken

Initial and final body weight among the different treatment groups had non- significantly difference (P>0.05). Total body weight gain and average daily body weight gain of supplemented groups (T2, T3andT4) were significantly higher than non supplemented group (T1) (P<0.0007). The present study agrees with (Tadesse *et al*., 2013) and (Ali, 2002) whom reported that body weight of chicken is affected by supplementary feeding, watering and health care . (Totsuka *et al*., 1993) reported that the weight gain increased significantly with increasing metabolize energy levels. Body weight gain and average daily body weight gain among supplemented groups were insignificantly differed (P>0.05) at the end of the experiment.

5.3. Supplemented Feed Conversion Efficiency

Supplemented feed conversion efficiency was measured between T2, T3 and T4, since T1 was without feed supplementation.FCE (g egg /g feed) was significantly higher in birds of T3 andT4 than birds in T2 (P<.0001). The difference could be due to high fiber content in T2 which limit the feed conversion. (Rashid *et al*., 2004) reported that high protein consumption significantly increased the feed conversion of the birds.

5.4. Egg production performance of Chicken

The average number of eggs laid per hen in the 3 months study was 44.32, 51.16, 53.44 and 52.20 for T1, T2, T3 and T4 respectively (Table 5). The result of the study indicated that hens without feed supplementation had significantly lower in hen- day egg production and hen-housed egg production compared to the hens fed supplementary feeds (P<0.0001). The average hen -day egg production of the supplemented groups and the non supplemented group were found 58.59 % and 49.24%, respectively. The result was consistent with (Almeida *et al.*, 2012) found higher egg production from using higher energy and higher protein combination of experimental diets compared to lower energy and lower protein diet combination. (Derseh, 2017) found Bovans brown supplemented with daily 60g/hen commercial layer ration increased by 25% egg production . (Ali, 2002) also reported that Sonali (Crossbred of Rhode Island Red male and Fayoumi female) supplemented with daily commercial layer ration 60g/hen enhanced egg production by12.6%. (Rashid *et al.*, 2004) reported that Sonali (Crossbred of Rhode Island Red male and Fayoumi female) supplemented with daily ration 60g with different level of energy and protein combination increased egg production by 12.9% and (Demeke, 2004) found Leghorn and local layers supplemented with a daily ration of 60 g/head, increased egg production by 46% and 15% respectively. However with regard to feed supplemented groups, hens in T3, T4, and T2 had recorded from higher to lower egg production performance respectively. The higher egg production obtained in the present study could be due to the supplementation of feed with higher protein content combined with slightly lower energy content and this agrees with the result of (Rashid, 2003) denotes that high protein level in diets improved the overall production performance of crossbred hens and the feeds scavenged by the birds are more deficient in protein than in energy. (Totsuka *et al*., 1993) reported that egg production increased with increasing Crude Protein levels. (Moges *et al.*, 2014) reported that Supplemented local scavenging hens with 60g of Maize and Niger Seed cake mix could produced an extra of 26.5 eggs per hen per six months and the better performance was due to the combined effect of both energy and protein feeds .

5.4.1. Egg weight and egg mass

In the current study egg weight of supplemented hens (T2,T3 and T4) have significantly higher ($P \leq 0.0001$) than the egg weight of un supplemented hens (T1) but there was no significant difference ($P>0.05$) among the egg weights of supplemented hens (T2,T3 and T4) .The current result agree with the result of (Ali, 2002) egg weight was significantly lower ($P<0.01$) in birds with no supplementation of feed at scavenging condition and no significantly differed ($P>0.05$) was observed between treatments with feed supplementation. (Rashid *et al*., 2004) reported that high protein consumption significantly increased the egg weight of the birds. (Minh, 2005) reported that egg weight of the scavenging groups was significantly higher for the protein supplemented compared to the energy supplemented. (Hussein *et al*., 1996) who reported significantly higher egg weight because of raising crude protein in the layer diet from 16 to 19% and (Almeida *et al.*, 2012) who reported significantly higher egg weight because of higher protein content of the experimental diet used. The current average egg weight recorded for Bovans Brown were relatively higher than average egg weight reported by (Derseh, 2017) that was supplemented with daily 60g/hen commercial layer ration under rural households (53.3g) and the difference might be due feed quality and environmental differences. Egg mass (g/hen/day) was significantly higher ($p<0.0001$) in T4 and T3 lower in T2 and T1 respectively. The current result agrees with (Rashid *et al*., 2004) , feed supplementation significantly improved egg mass output and (Bonekamp *et al*., 2010) reported that daily egg mass production increased significantly with increasing balanced protein.

5.5. Morbidity and Mortality of Chicken

In the present study there was no significant difference in mortality among the treatments ($p>0.05$).There was no any morbidity of hens observed during the trial period in all treatments but two hens from T4 were lost by predatory (wild cat) at the end week of the study. The current finding agree with (Tadesse, 2014) reported that predators were the major causes of year round losses of chicken in both low land (Rama) and mid land (Adwa) agro ecological zone of Tigray. But exotic breeds are more attacked or sensitive to predators. Moreover, (Guèye, 1998) reported that predation, disease and unknown reasons are the most causes for chicken mortality.

5.6. Egg Quality Parameters

5.6.1. Egg shell quality

The shell thickness and shell weight of the eggs were significantly lower in non supplemented birds compared to birds fed with supplementary diets ($p<0.0018$) (Table 6).The present result was agree with (Rashid *et al*., 2004) that the shell thickness of the eggs were significantly lower in fully scavenging birds compared to birds fed with supplementary diets. Poor nutrition is the most often cause of poor shell quality, especially lack of Ca and P in the diet of layers results in poor shell quality (Summers, 1995). (Zita *et al*., 2009) reported that difference in eggshell thickness was due to the effect of breed type, environmental condition and feed quality. The provision of adequate dietary minerals and vitamins is essential for good egg shell quality (Solomon, 2008). Dietary Ca supplementation should play an important role in maintaining the good eggshell quality (Arpášová *et al*., 2010). However there was no significant difference ($P>0.05$) in shell thickness and shell weight were observed among eggs collected from feed supplemented birds because limestone that influenced shell thickness and shell weight provided uniformly for T2,T3 and T4 .

5.6.2. Egg albumen weight, height and Hough unit

Albumin weight, albumin height and HU was not significantly differ among the treatments ($p>0.05$) (Table 6). The current result agree with (Rashid et al., 2004) where crossbred hens supplemented with high protein (19%) and low protein (15%) level feeds did not differ significantly in Albumin weight, albumin height and HU. (Fanimo ,1996) reported that neither energy nor protein levels affected albumen height, haugh unit score. (Williams, 1992) noted that nutrition has minor impact on albumen quality, and the decline in Hough units is mostly related to age of the hen and egg storage conditions. However layers used in the present experiment are in their first months of egg production, and the eggs used for quality analysis were also fresh. Hence, absence of difference in these parameters among the treatments indicates that feed supplementation did not affect albumin quality parameters .Therefore, the eggs collected from the different treatments were found within the range of to be ranked a good quality (70 -100HU). (Lewko and Gornowicz, 2009), suggested that the hens were with better productive performance.(Rajkumar *et al*., 2009) reported that brown egg layers produced eggs with higher HU. The height of the albumen determines the HU of the egg and the higher the height of the albumen, the greater the HU and the better the quality of the eggs. The value of albumen weight was consistent with differences in egg weight, which is in line with (Suk and Park, 2001) findings , that albumen weight is positively associated with egg weight.

5.6.3. Egg yolk quality

In the current study eggs collected from the different treatments for egg quality analyses are found no significant difference in egg weights ($P>0.05$) (Table 6).However feed supplemented hens in (T2, T3 and T4) have significantly higher Yolk weight than the egg yolk weights of non - supplemented hens in (T1) ($P<0.0001$).In the present study egg weight of supplemented hen's influences to increase especially the yolk weights of the eggs. However the present result disagrees with the finding of (Keshavarz and Nakajma, 1995) reported that compared two levels of protein (17 and 21%) in layer diets, and revealed that higher protein level did not influence yolk weight .Likewise, (Roland, 1980) also found no significant difference in yolk weight of eggs between 13.5, 16 and 20% protein in diets. The yolk height of the different treatment groups are found different significantly ($p<0.0042$).Yolk height of eggs in T3 and T4 found significantly higher compared to yolk height of eggs in T2 and T1 respectively. The yolk index of the present study is significantly higher in hens (T4 and T3) compared to hens in (T1 and T2) respectively ($P\leq0.0087$). The yolk index values of the eggs collected from all treatment groups in the present experiment are in the range of 0.42-0.44, which is within the accepted range of 0.33-0.50 for fresh eggs (Ihekoronye and Ngoddy, 1985).

5.6.3.1. Egg Yolk color

In the present study there was not significantly differ in yolk colour among the treatments ($p>0.05$) (Table 6). Average yolk colour points of eggs collected from T1, T2, T3 and T4 on the Roche scale were found 9.96, 9.91, 9.96 and10.02 respectively. The yolk colour of eggs collected from the different treatments had a deep yellow colour ranged from (8 to12) of Roche scale (Table 7). This result agree with (Silversides *et al.*, 2006) reported that village chicken roaming near the back yard could get enough xanthophylls (plant pigment) content of the diet consumed. (Rashid *et al.*, 2004) found that fully scavenging birds tended to produce eggs with higher yolk colour score. (Yenice *et al*., 2016) reported that yolk colour of BB eggs obtained from the family type system was superior (11.85) to that obtained from the cage (10.36) and free-range systems(10.42).The difference of the colour points might be due to feed quality difference. The deep yellow colour in scavenging birds might be due to the access of these birds to natural sources of feed. Green grass during scavenging might be responsible for carotenoid deposits in the yolk, which improves the yolk color. Therefore, if a hen has access to green grass or supplemented feed ingredients containing carotenoids/xanthophylls, it would be enough to give the yolk colour preferred by consumer.

5.7. Partial Budget Analysis

Average dry matter feed intake per bird, price of feed used per bird, cost of feed, cost of feed processing and mixing were used to calculate the variable costs. Net return was obtained from the difference between total variable cost and egg produced sold. The economic benefit was estimated by considering partial budget by using proper procedure (Upton, 1979). In the current study feed costs are the major costs that influenced the profitability of chicken rearing. In the present study 3324.00, 3385.68, 3499.00 and 3427.35 net return in Ethiopian birr was obtained from T1, T2, T3 and T4 respectively from sale of eggs within three months experimental period (Table 8). Net return increased as the level of dietary protein and dietary energy increased because these nutrients improved the production performance and egg quality traits. Ration (T3) with comparatively higher16.87% CP and with slightly lower energy 2752 kcal/DM Metabolisable energy formulated from locally available feed resources increased net income compared to T4and T2 and a good option and has remarkable profit for farmers.

CHAPTER 6: CONCLUSION AND RECOMMENDATION

6.1. Conclusion

In Ethiopia the major problem of poultry production is poultry feed scarcity as result the expected output of this sector remained very low. The use of alternative feeds which are not consumed by human being in poultry ration is a key determinant factor for successful poultry production.

The study was conducted to evaluate the effects of feed supplementation on feed intake, body weight change, feed conversion efficiency, egg production, morbidity, mortality, egg quality traits and profitability of Bovans Brown layers for 90 feeding trial days in central zone of Tigray.

Randomized complete block design was used with four treatments and five replications each. A total of one hundred Bovans Brown layers with uniform Body weight and age were blocked randomly into twenty farmers or replication five birds per farmer and were allocated randomly in to one of the four dietary treatments. The CP and ME content of treatment rations ranged 12.5-16.87% and 2245-2909.51kcal/ kg DM, respectively

The amount of feed consumed was determined by obtaining the difference between the quantity feed offered and the quantity feed remaining on the feed through. Body weight of the birds was measured at the beginning and end of the study. Egg quality traits were determined six times during the study period by taking three eggs from each farmer per two weeks.

The data were analyzed using the SAS (2008, version, 9.1.3) computer soft ware using analysis of variance (ANOVA) that is one way-ANOVA. Means differences in productive performances and egg quality traits were compared using Turkey's Standardized Range Test (HSD) method.

The present results clearly showed that feed supplementation significantly improved body weight gain, egg production, egg weight, egg mass , shell thickness ,shell weight, yolk weight and yolk height except albumen quality and yolk colour compared to non supplemented hens.

Therefore it could be concluded that under rural house hold condition feed supplementation increased egg production performance of chicken but there was variation on the level of egg production increment on different findings this might be due to differences on nutritional quality of the feed used, the variation on the level of feed supplementation, the available feed resource of the area and genotype of the birds used.

Generally egg production was improved by feed supplementation, when compared among the supplemented treatments T3 followed by T4 had the highest performance, which varied significantly from the performance of T2. The higher egg production obtained in treatments T3 followed by T4 could be due to the supplementation of feed with comparatively higher 16.87% CP and slightly lower energy 2752 kcal/kg ME diet could be better to supplement for chicken under farmers condition.

No morbidity and no mortality of chicken by disease was observed during the trial period and this could be due to the vaccination given to the chicken before the time of distribution which may help them in acquiring resistance against prevalent disease in the area and due to the presence of supplementary feeding and better follow up of the birds. However, exotic breeds are more attacked or sensitive to predator's and thief's attack because exotic breeds like local chicken are not fast and active to escape away from.

The main purpose of poultry production is to generate income; the costs must be kept to a minimum so as to ensure that the selling price of the eggs covers all costs plus a profit. However feed costs are the major costs that influenced the profitability of chicken rearing. In the current study the economic return in terms of partial budget analysis showed that in the order of T3 > T4 > T2 > T1 from sale of eggs, which is attributed net return increased as the level of dietary protein and dietary energy increased because these nutrients improved the egg production and egg weight of chicken compared with these hens in control group.

6.2. Recommendation

Supplementation of feed with higher protein content combined with slightly lower energy content diet could be recommended for a viable poultry production under rural house hold condition. However, since protein-rich feeds are expensive and the price of commercial poultry feed produced by private company is too expensive for small holder farmers to regularly feed their chickens and rises from time to time. Hence, future research should focus on the possibility of using cheap conventional and non-conventional protein-rich feed resources as feed supplement for scavenging chicken in rural areas.

The egg quality from Bovans Brown layers was a good quality at village level, while the average number of eggs/bird/year may need further study through considering the amount of feed provided by the farmers and scavenging feed resources on that area by crop analysis.

REFERENCES

ABEBE, H. 1992. Terminal report on the comparative evaluation of native chicken in the Hararge Administrative region and their crosses with the single comb white Leghorn. *Memeographed report. Alemaya University of Agriculture***,** 22-27.

ABERA, M. 2000. *Comparative studies on performance and physiological responses of Ethiopian indigenous (Angete Melata) chicken and their f1 crosses to long term heat exposure.* PhD dissertation, Martin-Luther University. Halle-Wittenberg Germany.

ADAMS, A. & CRAIG, J. 1985. Effect of crowding and cage shape on productivity and profitability of caged layers: A survey. *Poultry Science,* 64**,** 238-242.

AOoARD. 2016. Aduwa Office of agriculture and rural development. Livestock senses.

AKLILU, H., ALMEKINDERS, C., UDO, H. & VAN DER ZIJPP, A. 2007. Village poultry consumption and marketing in relation to gender, religious festivals and market access. *Tropical Animal Health and Production,* 39**,** 165-177.

AKLILU, H., UDO, H., ALMEKINDERS, C. & VAN DER ZIJPP, A. 2008. How resource poor households value and access poultry: Village poultry keeping in Tigray, Ethiopia. *Agricultural Systems,* 96**,** 175-183.

ALDERS, R. G. 2004. *Poultry for profit and pleasure,* Food & Agriculture Org.

ALEMU, D., DEGEFE, T., FEREDE, S., NZIETCHUENG, S. & ROY, D. 2008. Overview and background paper on Ethiopia's poultry sector: Relevance for HPAI research in Ethiopia.

ALEMU, Y. & GUENTHER, K. 1992. Studies on the chemical composition of some poultry feeds of Ethiopian origin. *Beitrage zur Tropischen Landwirtschaft und Veterinarmedizin,* 30**,** 427-450.

ALEMU, Y. & TADELLE, D. 1997. The status of poultry research and development in Ethiopia, research bulletin No. 4, poultry commodity research program Debrezeit Agricultural research center. *Alemaya University of agriculture, Ethiopia,* 62.

ALI, M. S. 2002. Study on the effect of feed supplementation to laying hen under the rural condition of Bangladesh. *Unpublished M. Sc. thesis, The Royal Veterinary and Agricultural University, Copenhagen, Denmark***,** 210.

ALMEIDA, V., DIAS, A., BUENO, C., COUTO, F., RODRIGUES, P., NOGUEIRA, W. & FARIA FILHO, D. 2012. Crude protein and metabolizable energy levels for layers reared in hot climates. *Revista Brasileira de Ciência Avícola,* 14**,** 203-208.

ALTAMIRANO, W. 2005. *Egg production of two breeds and three diets in the highland of Bolivia. The Royal Veterinary and Agricultural University, Copenhagen.* MSc Thesis).(Available. at. http://www. poultry. life. ku. dk/Information_resources/Refe rences/Poultry_References).

ARPÁŠOVÁ, H., HALAJ, M. & HALAJ, P. 2010. Eggshell quality and calcium utilization in feed of hens in repeated laying cycles. *Czech Journal of Animal Science,* 55**,** 66-74.

BAIN, M. 2005. Recent advances in the assessment of eggshell quality and their future application. *World's poultry science Journal,* 61**,** 268-277.

Bonekamp, R.P.R.T., A. Lemme, P.J.A. Wijtten And J.K.W.M. Sparla .2010. Effects of amino acids on egg number and egg mass of brown (heavy breed) and white (light breed) laying hens. Poult. Sci., 89: 522-529.

BOVŠKOVÁ, H., MIKOVA, K. & PANOVSKÁ, Z. 2014. Evaluation of Egg Yolk Colour. *Czech J. Food Sci. Vol,* 32**,** 213-217.

BUSH, J. 2006. The threat of avian flu predicted impacts on rural livelihoods in Southern Nation, Nationalities and Peoples Region (SNNPR), Ethiopia. *The Food Economy Group*.

CAREY, J., KUO, F. & ANDERSON, K. 1995. Effects of cage population on the productive performance of layers. *Poultry Science,* 74**,** 633-637.

CSA ,2016. Agricultural sample survey. Report on livestock and livestock characteristics. 2(583): 20-21. CSA, Addis Ababa,Ethiopia.

CHATTERJEE, R., RAI, R., PRAMANIK, S., SUNDER, J., SENANI, S. & KUNDU, A. 2007. Comparative growth, production, egg and carcass traits of different crosses of Brown Nicobari with White Leghorn under intensive and extensive management systems in Andaman, India. *Livestock Research for Rural Development,* 19**,** 1Á6.

CHUKWUKA, O., OKOLI, I., OKEUDO, N., UDEDIBIE, A., OGBUEWU, I., ALADI, N., IHESHIULOR, O. & OMEDE, A. 2011. Egg quality defects in poultry management and food safety. *Asian Journal of Agricultural Research,* 5**,** 1-16.

DAGHIR N. J. 2001. Poultry production in hot climates. Faculty of Agricultural Sciences United Arab Emirates University. 1-8p.

DANA, N. & OGLE, B. 2002. Effects of scavenging on diet selection and performance of Rhode Island Red and Fayoumi breeds of chicken offered a choice of energy and protein feeds. *Tropical Animal Health and Production,* 34**,** 417-429.

DANA, N., VAN DER WAAIJ, L. H., DESSIE, T. & VAN ARENDONK, J. A. 2010. Production objectives and trait preferences of village poultry producers of Ethiopia: implications for designing breeding schemes utilizing indigenous chicken genetic resources. *Tropical animal health and production,* 42**,** 1519-1529.

DAWUD, I., BOLU, S., ABU, O. & AKLILU, H. 2014. *Effects Of Noug Seed Cake (Guizotiaabyssinica) On The Performance Of Growing White Bovan Cockerels In Ethiopian Highland*. *Journal of Agricultural Research and Development,* 13**,** 25-33.

DEMEKE, S. 2004. Egg production performance of local and White Leghorn hens under intensive and rural household conditions in Ethiopia. *Livestock Research for Rural Development,* 16**,** 2004.

DEPERSIO, S. A. 2011. Effects of feeding diets varying in nutrient density to Hy-Line W-36 laying hens on production performance and profitability.

DERSEH, G. T. 2017. *Productive And Reproductive Performances Of Bovans Brown And Koekoek Chicken Breeds Under Varied Seasons And Feeding Regimes In South Wollo Zone, Ethiopia.* Addis Ababa University.

DESSIE, T. 1997. The role of scavenging poultry in integrated farming systems in Ethiopia.

DESSIE, T. & OGLE, B. 1996. *A survey of village poultry production in the central highlands of Ethiopia. Part I of M. Sc.* Thesis. Swedish University of Agricultural Sciences, Department of Animal Nutrition and Management.

DESSIE, T. & OGLE, B. 2000. Nutritional status of village poultry in the central highlands of Ethiopia as assessed by analyses of crop contents. *Ethiopian Journal of Agricultural Science,* 17**,** 47-56.

DESSIE, T. & OGLE, B. 2001. Village poultry production systems in the central highlands of Ethiopia. *Tropical Animal health and production,* 33**,** 521-537.

DESSIE, T., TADESSE, M., YAMI, A. & PETERS, K. 2003. Village chicken production systems in Ethiopia: 1. Flock characteristics and performance.

DEVENDRA, C. 1985. Non-conventional feed resources in Asia and the Pacific.

ELWARDANY, A., SHERIF, B., ENAB, A., ABDEL-SAMI, A., MARAI, I. & METWALLY, M. 1998.Some performance traits and abdominal fat contents of three Egyptian indigenous laying breeds. First international conference on animal production and health in semi-arid areas, El Aris. 471-481.

FAO, 1990. Guide to Food and Agriculture Organization (FAO) Documents (Website).

FAO, 2007. Poultry sector country review, Animal Production and Health Division, Emergency center for trans-boundary animal diseases socio economics, production and biodiversity unit, Food and Agriculture Organization of the United, Nations, Rome., Italy.

Famino, A.O. 1996. Effect of feeding varying protein and energy levels on the performance and

egg quality of layers in the tropics. Int. J. Anim. Sci., 11: 209-212.

FAO, F. D. 2009. Food and Agriculture Organization of the United Nations, Rome (2004).

FAO ,2013. Food and Agriculture Organization of the United Nations. Poultry development review

FAROOQ, M., MIAN, M., ALI, M., DURRANI, F., ASGHAR, A. & MURQARRAB, A. 2001. Egg traits of Fayumi birds under subtropical conditions. *Sarhad Journal of Agriculture (Pakistan)*.

FAROOQ, M., MIAN, M., DURRANI, F. & SYED, M. 2002. Feed consumption and efficiency of feed utilization by egg type layers for egg production. *Livestock Research for Rural Development,* 14.

FARRELL, D. 2013. The role of poultry in human nutrition. *the role of poultry in human nutrition***,** 2.

FAOSTAT, F. 2013. Agriculture organization of the united nations (2012). *FAO, Retrieved am from http://faostat3. fao. org/faostat-gateway/go/to/download/Q/QC/S. Acceso,* 20.

FIKRU, S., URGE, M. & ANIMUT, G. 1996. Effects of feeding processed kidney bean meal (Phaseolus vulgaris) instead of soybean meal on qualities of eggs of white leghorn hens.

FITSUM, M. & ALIY, M. 2014. Poultry Production System and Role of Poultry Production in Tigray Region, Northern Ethiopia: A Review. *issues*, 4.

FLEMMING, E. 2005. Contolling late egg size. *World Poultry,* 21**,** 14-15.

FRONING, G. 1998. Recent advances in egg products research and development.

GELETA, T. & LETA, S. 2015.Effect of dietary energy and protein combination on egg production performance of Fayoumi chicken.

GIRMA, M., URGE, M. & ANIMUT, G. 2011. Ground Prosopis juliflora Pod as Feed Ingredient in Poultry Diet: Effects on Laying Performance and Egg Quality. *International Journal of Poultry Science,* 10**,** 879-885.

GOROMELA, E., KWAKKEL, R., VERSTEGEN, M. & KATULE, A. 2006. Strategies to optimize the use of scavengeable feed resource base by smallholders in traditional poultry production systems in Africa: A review. *African Journal of Agricultural Research,* 1**,** 91-100.

GUÈYE, E. H. F. 2000. The role of family poultry in poverty alleviation, foodsecurity and the promotion of gender equality in rural Africa. *Outlook on Agri.* 29 (2): 129-136.

HAUGH, R. 1937. The Haugh unit for measuring egg quality.

HEUZÉ, V., THIOLLET, H., TRAN, G., HASSOUN, P., BASTIANELLI, D. & LEBAS, F. 2016. Niger (# Guizotia abyssinica#).

HUSSEIN, A., CANTOR, A., PESCATORE, A. & JOHNSON, T. 1996. Effect of dietary protein and energy levels on pullet development. *Poultry science,* 75**,** 973-978.

HUNTON ,P. 1995. Egg production, processing and marketing. In: World Poultry Science, Elsevier, Tokyo. pp 457-480.

IHEKORONYE, A. I. & NGODDY, P. O. 1985. *Integrated food science and technology for the tropics*, Macmillan.

IQBAL, A., KHALIL, I. A., ATEEQ, N. & KHAN, M. S. 2006. Nutritional quality of important food legumes. *Food Chemistry,* 97**,** 331-335.

ISLAM, M., BULBUL, S., SEELAND, G. & ISLAM, A. 2001. Egg quality of different chicken genotypes in summer and winter. *Pak. J. Biol. Sci,* 4**,** 1411-1414.

JACOB, J. P., MILES, R. D. & MATHER, F. B. 2000. Egg quality. *Cooperative Extension Service, Institute of Food and Agricultural Sciences (IFAS), University of Florida PS,* 24.

JESUYON, O. 2016. *Growth Pattern, Reproductive Performance And Seasonal Sensitivity Of Bovan Nera And Isa Brown Parent-Stock Chicken In Ibadan Nigeria.*

KELLEMS, R. O. & CHURCH, D. C. 2002. *Livestock feeds and feeding*, Prentice Hall Upper saddle River, NJ

.

Keshavarz, K. and S. Nakajma, 1995. The effect of dietary manipulations of energy, protein, and fat during the growing and laying periods on early egg weight and egg component. Poultry Sci., 74: 50-61.

KHAN, M., KHATUN, M. & KIBRIA, A. 2002. Study the quality of eggs of different genotypes of chicken under semi-scavenging system at Bangladesh. *Pak J Biol Sci,* 7**,** 2163-2166.

KITALYI, A. J. 1998. *Village chicken production systems in rural Africa: Household food security and gender issues*, Food & Agriculture Org.

KONDOMBO, S., NIANOGO, A., KWAKKEL, R., UDO, H. & SLINGERLAND, M. 2003. Comparative analysis of village chicken production in two farming systems in Burkina Faso. *Tropical Animal Health and Production,* 35**,** 563-574.

KONDOMBO, S. R. 2005. *Improvement of village chicken production in a mixed (chicken-ram) farming system in Burkina Faso*.

LEESON, S., CASTON, L. & SUMMERS, J. 1997. Layer performance of four strains of Leghorn pullets subjected to various rearing programs. *Poultry science,* 76**,** 1-5.

LEESON, S. & SUMMERS, J. 2001. Scoot's Nutrition of the Chicken. *University Book. Guelph, Canada*.

LEWKO, L. & GORNOWICZ, E. 2009. EGG ALBUMEN QUALITY AS AFFECTED BY BIRD ORIGIN KSZTAŁTOWANIE SIĘ JAKOŚCI BIAŁKA JAJA W ZALEŻNOŚCI OD POCHODZENIA PTAKA. *Journal of Central European Agriculture,* 10.

LITTELL, R. C., STROUP, W. W. & FREUND, R. J. 2002. *SAS for linear models*, SAS institute.

MAAZA, S. 1981. *Comparative laboratory and animal evaluation and estimation of nutritive values of Noug and peanut seed cake.* MSc. Thesis.

MEKONNEN, H., MULATU, D., KELAY, B. & BERHAN, T. 2010. Assessment of the nutritional status of indigenous scavenging chicken in Ada'a district, Ethiopia. *Tropical Animal Health and Production,* 42**,** 123-130.

MENGESHA, M., TAMIR, B. & DESSIE, T. 2011. Village chicken constraints and traditional management practices in Jamma District, South Wollo, Ethiopia. *Livestock Research for Rural Development,* 23.

METAFERIA, F., CHERENET, T. G., ABNET, F., TESFAY, A., ABDI, J. & GULILAT, W. 2011. A review to improve estimation of livestock contribution to the national GDP.

MINH, D. V. 2005. *Effect of supplementation, breed, season and location on feed intake and performance of scavenging chicken in Vietnam*.

MOGES, F., NEGA, M. & ZELEKE, G. 2014. Demonstration of Maize and Niger Seed Cake Supplementation on Egg Production Performance of Local Scavenging Hens in Selected Districts of Western Amhara, Ethiopia. *World's Vet. J,* 4**,** 30-34.

MONIRA, K., SALAHUDDIN, M. & MIAH, G. 2003. Effect of breed and holding period on egg quality characteristics of chicken. *International Journal of Poultry Science,* 2**,** 261-263.

MOREDAA, E. & MESEKEL, K. G. 2016. Importance of Traditional, Small Scale and Commercial Poultry Production in Ethiopia: A Review. *British Journal of Poultry Sciences,* 5**,** 01-08.

NRC 1994. National Research Council. Nutrient Requirements of Poultry: Ninth Revised Edition. Washington, DC: The National Academies Press, 1994. doi:10.17226/2114

NORTH, M. & BELL, D. 1984. Breeder management. *Commercial Chicken Production Manual. The Avi. Publishing Company. Inc. Westport, Connecticut***,** 240-321.

NZIETCHUENG, S. 2008. Characterization of poultry production systems and potential pathways for the introduction of highly pathogenic avian influenza in Ethiopia. Draft Report. *International Livestock Research Institute*.

OJEDAPO, L., ADEDEJI, T. & OLAYEMI, T. Phenotypic correlation between internal and external egg quality traits of a commercial layer strain. Proceedings of the 33rd Annual Conference of Nigerian Society for Animal Production, 2008. 31-33.

OKE, O., LADOKUN, A. & ONAGBESAN, O. 2014. Quality parameters of eggs from chicken reared in deep litter system with or without access to grass or legume pasture. *Magnesium (mg/g),* 1**,** 2.12.

OKEUDO, N., ONWUCHEKWA, C. & OKOLI, I. 2003. Effect of oil treatment and length of storage on the internal quality, organoleptic attributes and microbial profile of chicken eggs. *Tropical Animal Production Investigation,* 6**,** 63-70.

OKOLI, I. & UDEDIBIE, A. 2000. Effect of oil treatment and storage temperature on egg quality. *Journal of Agriculture and Rural Development,* 1**,** 55-60.

ONAGBESAN, O., BRUGGEMAN, V., DE SMIT, L., DEBONNE, M., WITTERS, A., TONA, K., EVERAERT, N. & DECUYPERE, E. 2007. Gas exchange during storage and incubation of Avian eggs: effects on embryogenesis, hatchability, chick quality and post-hatch growth. *World's Poultry Science Journal,* 63**,** 557-573.

PAGANI, P. & WOSSENE, A. 2008. Review of the new features of the Ethiopian poultry sector. Biosecurity implications. *Food and Agriculture Organization of the United Nations (FAO)*.

QUNAIBET, M., ELWAFA, E. & MANSOUR, M. 1992. Improving the competitive status of Saudi broiler industry. *J. King Saud University Agri. Sci,* 4**,** 164-184.

RAHMAN, M., SORENSEN, P., JENSEN, H. A. & DOLBERG, F. 1997. Exotic hens under semi scavenging conditions in Bangladesh. *Livestock Research for Rural Development,* 9**,** 1-11.

RAJKUMAR, U., SHARMA, R., RAJARAVINDRA, K., NIRANJAN, M., REDDY, B., BHATTACHARYA, T. & CHATTERJEE, R. 2009. Effect of genotype and age on egg quality traits in naked neck chicken under tropical climate from India. *Int. J. Poult. Sci,* 8**,** 1151-1155.

RASHID, M. 2003. Nutritional status of scavenging chicken with special emphasis on energy and protein supplementation under rural conditions in Bangladesh. *Master of Science). Royal Veterinary and Agricultural University: Denmark*.

RASHID, M., ISLAM, M., ROY, B., JAKOBSEN, K. & LAURIDSEN, C. 2004. Effect of dietary supplementation of energy and protein on production performance and egg quality of scavenging crossbred hens in rural areas under tropical conditions. *Livestock Research for Rural Development,* 16**,** 479-481.

RETA, D. 2009. Understanding the role of indigenous chicken during the long walk to food security in Ethiopia. *Red,* 19**,** 21-5.

RIISE, J. C., PERMIN, A., MCAINSH, C. V. & FREDERIKSEN, L. 2005. Keeping village poultry: a technical manual on small-scale poltry production.

ROBERTS, M. V. 2010. *Dualities: A theology of difference*, Westminster John Knox Press.

Roland Sr, D. A. 1980. Egg shell quality. 1. Effect of dietary manipulations of protein, amino acids, energy, and calcium in aged hens on egg weight, shell weight, shell quality, and egg production.Poultry Science, 59: 2038-2046.

ROLAND SR, D. A. 1988. Research note: egg shell problems: estimates of incidence and economic impact. *Poultry Science,* 67**,** 1801-1803.

ROQUE, L. & SOARES, M. 1994. Effects of eggshell quality and broiler breeder age on hatchability. *Poultry science,* 73**,** 1838-1845.

ROSE, S. 1997. *Principles of poultry science*, Cab International.

SABRI, H. M., WILSON, H. R., HARMS, R. H. & WILCOX, C. J. 1999. Genetic parameters for egg and related characteristics of white leghorn hens in a subtropical environment. *Genetics and Molecular Biology,* 22**,** 183-186.

SHI, S., WANG, K., DOU, T. & YANG, H. 2009. Egg weight affects some quality traits of chicken eggs. *J. Food Agr. Environ,* 7**,** 432-434.

SILVERSIDES, F., SCOTT, T., KORVER, D., AFSHARMANESH, M. & HRUBY, M. 2006. A study on the interaction of xylanase and phytase enzymes in wheat-based diets fed to commercial white and brown egg laying hens. *Poultry science,* 85**,** 297-305.

SOLOMON, D. 2008. . Poultry sector country review: from the report; HPAI prevention and control strategies in Eastern Africa. The structure, marketing and importance of the commercial and village poultry industry: An analysis of the poultry sector in Ethiopia. Food and agriculture organization of the United Nations 2007, Re-edited September 2008. *International Journal of Poultry Science.*

SOLOMON, M. 1992. *The effect of method of processing of oil seed cakes in Ethiopia on their nutritive value.* PhD. Thesis, University of Bonn, Germany.

SONAIYA, E. & SWAN, S. 2004. FAO Animal Production and Health 1. Manual. Small Scale Poultry Production. Technical guide. *Available online (accessed on 20 September 2014) http://www. fao. org/3/a-y5169e. pdf.*

SONAIYA, E. B. 2004. Direct assessment of nutrient resources in free-range and scavenging systems. *World's Poultry Science Journal,* 60**,** 523-535.

SAS 2008. SAS Users Guide: Statstics,Version 9.1. SAS Institute Inc., Cary, NC.

SUK, Y. & PARK, C. 2001. Effect of breed and age of hens on the yolk to albumen ratio in two different genetic stocks. *Poultry Science,* 80**,** 855-858.

SUMMERS, J. D. 1995. Reduced dietary phosphorus levels for layers. *Poultry science,* 74**,** 1977-1983.

TADELLE, D. 1996. Studies on village poultry production systems in the central highlands of Ethiopia.

TADELLE, D., ALEMU, Y. & PETERS, K. 2000. Indigenous chicken in Ethiopia: genetic potential and attempts at improvement. *World's Poultry Science Journal,* 56**,** 45-54.

TADELLE, D., KIJORA, C. & PETERS, K. 2003. Indigenous chicken ecotypes in Ethiopia: growth and feed utilization potentials. *International Journal of Poultry Science,* 2**,** 144-152.

TADELLE, D., NIGUSIE, D., ALEMU, Y. & PETERS, K. 2002. The feed resource base and its potentials for increased poultry production in Ethiopia. *World's Poultry Science Journal,* 58**,** 77-87.

TADESSE, A. 2014. Production and Reproduction Performance of Rural Poultry in Lowland and Midland Agro-Ecological Zones of Central Tigray, Northern Ethiopia. *British Journal of Poultry Sciences,* 3**,** 06-14.

TADESSE, D., ESATU, W., GIRMA, M. & DESSIE, T. 2015. Comparative study on some egg quality traits of exotic chicken in different production systems in East Shewa, Ethiopia. *African Journal of Agricultural Research,* 10**,** 1016-1021.

TADESSE, D., SINGH, H., ESATU, A. M. W. & DESSIE, T. 2013. Study on productive performances and egg quality traits of exotic chicken under village production system in East Shewa, Ethiopia. *African Journal of Agricultural Research,* 8**,** 1123-1128.

TEGENE, N. 1992. Dietary status of smallholder local chicken in Leku, Southern Ethiopia. *Sinet,* 15**,** 57-67.

TESFAY, Y., GEBRELIBANOS, A., WOLDEMARIAM, D. & TILAHUN, H. 2016. Feed resources availability, utilization and marketing in central and eastern Tigray, northern Ethiopia.

Totsuka, K., Okazaki, Y., Yamamoto, A., Koide, K., Watanabe, E., Toyomizu, M. and Ishibashi,

T. 1993. Effect of dietary crude protein and metabolisable energy levels on the performance of laying hens. Japanese Poultry Science, 30: 1-15.

UCHEGBU, M. C., HERBERT, U., OGBUEWU, I. P., NWAODU, C. H., ESONU, B. O. & UDEDIBIE, A. B. I. 2013. Performance and egg quality characteristics of layers fed diets containing combinations of brewers dried grains, jack bean and cassava root meal.

UPTON, M. 1979. *Farm management in Africa: the principles of production and planning*, Cambridge Univ Press.

WETHLI, E. [The results of some nutritional trials on the use of local raw materials in rations for chicken and ducks]. Seminario de Producao Animal, Maputo (Mozambique), 2-7 Dec 1985, 1986.

WILLIAMS, K. 1992. Some factors affecting albumen quality with particular reference to Haugh unit score. *World's Poultry Science Journal,* 48**,** 5-16.

WILSON, K. J. & BEYER, R. S. 2000. Poultry nutrition information for the small flock.

WOSSENE, A. 2006. Poultry bio-security study in Ethiopia. *A consultancy report for food and Agriculture Organization of the United Nations*.

YAMI, A. 1981. Laboratory evaluation and estimation of nutritive value of some feedstuffs produced in Alemaya Woreda. *An MSc Thesis presented to School of Graduate Studies, Alemaya University***,** 61.

YAMI, A. 1995. Poultry production in Ethiopia. *World's Poultry Science Journal,* 51**,** 197-201.

YENICE, G., KAYNAR, O., ILERITURK, M., HIRA, F. & HAYIRLI, A. 2016. Quality of Eggs in Different Production Systems. *Czech Journal of Food Science,* 34.

YIRGU, T., TESFAYE, E. & ASSEFA, G. 2017. Poultry Feed Resources and Coping Mechanisms of Challenges in Sidama Zone, Southern Ethiopia.

YITBAREK, M. B. & ATALEL, W. 2013. Constraints and opportunities of village chicken production in debsan tikara keble at gonder zuria woreda, north gonder, Ethiopia. *Scientific Journal of Veterinary Advances,* 2**,** 118-124.

ZITA, L., TŮMOVÁ, E. & ŠTOLC, L. 2009. Effects of genotype, age and their interaction on egg quality in brown-egg laying hens. *Acta Veterinaria Brno,* 78**,** 85-91.

APPENDIX

Appendix I. Cost of Feed Ingredients

Ingredient	Price/kg (birr)	Source
Gouge seed cake	6.3	AA
Sesame meal	12	SA
Maize	5.15	AM
Limestone	6	AM
Salt	6.5	AM

AA=Addis Ababa; SA=Shire-Adidaero, AM= Adigrat Market

Appendix II. Analysis of variance summary result for feed intake, body weight and egg laying performance of farmer managed Bovans brown layers fed on different locally available rations.

Source	DF	SST	MST	F- value	Pr>F.	CV%
Blocking effect	3	40.00	2.50	0.00	1.00	52.70463
%DMI (g/hen/day)	3	35360.27093	11786.75536	3.885E7	<.0001	0.023918
Initial BW(g)	3	11315.20000	737.1	0.05	0.9835	1.770349
Final BW(g)	3	13067.80000	1075.16667	0.42	0.7411	1.775305
BW gain (g)	3	4755.80000	1123.766667	9.55	0.0007	19.43481
AD Body weight gain (g)	3	0.58746320	0.139005752	9.60	0.0007	19.41408
Total egg/bird	3	252.7520000	83.4620000	457.58	<.0001	0.848478
HDEP%	3	384.2607200	121.918228	85.07	<.0001	2.116074
HHEP %	3	358.6318950	113.5936158	81.72	<.0001	2.094608
Egg weight(g)	3	3.97660000	1.020965	13.53	0.0001	0473586
EM (g/hen/day)	3	105.3717750	32.9993242	66.31	<.0001	2.262936
FCE (g eggs /g feed)	3	4.17749376	1.39139107	5446.32	<.0001	2.860113
Morbidity%	3	0	0	0	.	.
Mortality%	3	1520.00000	180.00000	1.00	0.4182	447.2136

DF= degree of freedom; SST= sum square total; MST=mean square total; CV= coefficient of variance; prob. =probability.

Appendix III. Analysis of variance summary result for egg quality parameters of farmer managed Bovans brown layers fed on different locally available rations.

Source	DF	SST	MSTF value	Prob>F	CV%	
Blocking effect	3	0.0	0.0	0.0	1.00	52.70463
Sample egg weight(g)	3	44.50638	4.98862083	1.20	0.3431	2.636244
Shell thickness(mm)	3	0.0039	0.000855	8.00	0.0018	2.564730
Shell weight(g)	3	1.16918	0.26290083	7.98	0.0018	3.270454
Albumen weight(g)	3	27.209655	2.247355	0.43	0.7361	3.367903
Albumen height(mm)	3	1.79498	011605917	0.04	0.9878	4.149836
Hough unit	3	38.02808	2.59940167	0.12	0.9483	1.689922
Yolk weight(g)	3	11.6998	3.41306167	29.38	<.0001	2.384025
Yolk height(g)	3	3.69062	0.78273583	6.58	0.0042	2.006274
Yolk diameter(cm)	3	0.080175	0.01712667	6.73	0.0038	1.255872
Yolk index	3	0.00292	0.00139333	5.48	0.0087	2.216550
Yolk colour	3	1.5695	0.106	0.11	0.955	3.113

DF= degree of freedom; SST= sum square total; MST=mean square total; CV= coefficient of variance; prob. =probability'

Appendix IV. Weekly average hen-day egg production of Bovans Brown layers during the experimental period (data used for figure 2)

Weeks

Treatments	1	2	3	4	5	6	7	8	9	10	11	12
1	57.7	55.4	45.4	49.1	49.7	49.1	49.7	48.6	44	49.7	46.3	52
2	53.1	56.6	52.6	45.7	46.9	44	60.57	61.7	61.7	65	58.9	68
3	61	55.4	55.4	53.7	56.6	58.3	49.4	55.4	64	67.4	62.9	70
4	61	52	54.3	58.3	53	57.7	47.4	51.4	64.6	64	65	66

Appendix V. Weekly average hen-housed egg production of Bovans brown layers during the experimental period (data used for figure 3)

Treatments	Weeks											
	1	2	3	4	5	6	7	8	9	10	11	12
1	57.7	55.4	45.4	49.1	49.7	49.1	49.7	48.6	44	49.7	46.3	52
2	53.1	56.6	52.6	45.7	46.9	44	60.57	61.7	61.7	65	58.9	68
3	61	55.4	55.4	53.7	56.6	58.3	49.4	55.4	64	67.4	62.9	70
4	61	52	54.3	58.3	53	57.7	47.4	51.4	64.6	64	65	62.85

Appendix VI . Data collection sheet for chicken performance

Name of the farmer (T--.R--.)-------------------------- ---

Record keeping format for each replications and treatments

Daily layers feed, health, egg production and egg weight records

Month------------------

<table>
<tr><td rowspan="3">No.</td><td rowspan="3">Date</td><td colspan="3" rowspan="2">Daily feed ration(gm)</td><td colspan="3">Health condition</td><td colspan="3">Egg production</td></tr>
<tr><td rowspan="2">No. ill</td><td rowspan="2">No.culled</td><td rowspan="2">No. dead</td><td rowspan="2">No. birds</td><td rowspan="2">Total egg laid</td><td rowspan="2">egg mass</td></tr>
<tr><td>Offered</td><td>Refusal</td><td>Intake</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

No.= number

Appendix VII. Egg quality data collection sheet for each replications and treatments

Month---------

Treatments	EWT	ALHT	ESWT	AWT	YHT	YDM	YWT	YC

N/B ; EWT –egg weight, ALHT-Albumin height , ESWT- egg shell weight , AWT-Albumin weight , YHT-yolk height, YDM-yolk diameter, YWT- yolk weight , YC-yolk colour.